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(71) Applicant (for all designated States except US): DIGITAL VIDEO EXPRESS, L.P. [US/US]; 570 Herndon Parkway, Herndon, VA 20170 (US).

(72) Inventors; and
(75) Inventors/Applicants (for US only): GOLDSCHLAG, David, M. [US/US]; 11209 Bybee Street, Silver Spring, MD 20902 (US). KRAVITZ, David, W. [US/US]; 4311–B Ramona Drive, Fairfax, VA 22030 (US).

(74) Agents: DEVINSKY, Paul et al.; McDermott, Will & Emery, 600 13th Street, N.W., Washington, DC 20005–3096 (US).

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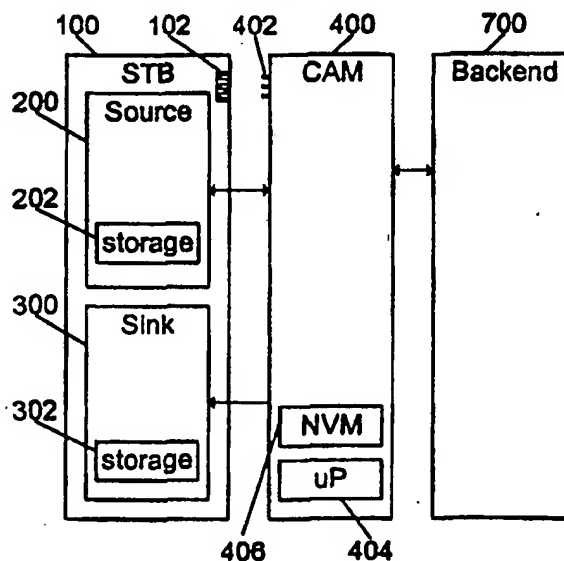
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(54) Title: INFORMATION ACCESS CONTROL SYSTEM AND METHOD

(57) Abstract

An information access control system and method which prevents unauthorized access from accessing the information. The apparatus includes a set top box (100) which receives the information from a broadcast stream or recorded medium, or other source and a conditional access module. The set top box (100) is paired with the conditional access module (400) such that they have a shared secret key which is used to send communications to each other. A pirate attempting unauthorized access does not have the shared secret key and thus can not receive the communications. The apparatus and method further require that the set top box (100) and the conditional access module (400) follow one of a plurality of protocols in communicating with each other. A pirate attempting unauthorized access will not able to follow the protocols.

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An information access control system and method which prevents unauthorized access from accessing the information. The apparatus includes a set top box (100) which receives the information from a broadcast stream or recorded medium, or other source and a conditional access module. The set top box (100) is paired with the conditional access module (400) such that they have a shared secret key which is used to send communications to each other. A pirate attempting unauthorized access does not have the shared secret key and thus can not receive the communications. The apparatus and method further require that the set top box (100) and the conditional access module (400) follow one of a plurality of protocols in communicating with each other. A pirate attempting unauthorized access will not able to follow the protocols.

INFORMATION ACCESS CONTROL SYSTEM AND METHOD

Field Of The Invention

The present invention relates to an information access system and method for
preventing an unauthorized access to information. More particularly, the present
5 invention relates to an apparatus and method for using a renewable component to
authorize access to information. More particularly still, the invention relates to a method
and apparatus for controlling the interaction between a backend system and devices for
generating and processing information.

10 ## Background Of The Invention

Preventing unauthorized access to information is an important problem in
numerous applications. The present invention broadly relates to and provides a solution
to this problem. In some commercial applications, where the information includes, for
example, valuable audio or video information, unauthorized access by those who obtain
15 the information reduces the profit margin of the information provider(s), who typically
provide the information, e.g. to various listener and/or viewers, for a fee. While the
description which follows may sometimes use audio/video context as an example of
information to be provided, the invention is not so limited and may equally apply to any
type of information or content data from any source, such as audio and/or video data or
20 other type of data or executables. The unauthorized assessor is an information pirate,
and can pose a serious threat to an information provider by inducing others to pirate the
information as well. More particularly, the pirate can generally sell pirated access to the
information at a lower cost than the legitimate information provider because the pirate

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obtains access to the information by using the legitimate provider's infrastructure and therefore does not have to invest resources to produce and disseminate the information. This becomes even a greater concern where the pirate can copy and mass produce a relatively inexpensive component which allows a large number of users to obtain access

5   to the information without authorization by the legitimate information provider. As a result, information providers have resorted to increasingly expensive and complex schemes to prevent unauthorized access to their information content, i.e. to prevent pirating.

One plan for controlling access to information involves the use of an IRD

10   (integrated receiver device) with smart cards as a security module. This plan was proposed by Fiat and Schamir in a paper titled "How To Prove Yourself: Practical Solutions To Identification And Signature Problems" The Weizmann Institute of Science, Rehovot Israel (1986), and involves the use a trusted center to encode a smart card with personal information and secret values relating to the access. The smart card

15   proves its identify to a verifier (IRD) which in turn must have knowledge of the secret values used to place the information onto the smart card. While the Fiat-Schamir plan is designed to make it difficult to forge personal information of one card, it does not prevent mass distribution of the forged card when and if the pirate has broken the smart card secrets used to prove identity. Also see U.S. Patent No. 4,748,688 to Schamir.

20   Another approach is described in U.S. patent 5,481,609 to Cohen et al, which uses a smart card in a system for controlling access to broadcast transmissions. Cohen uses a verifier function in an IRD to authenticate the authenticity of a smart card, a secret-learning operation, and a blacklisting operation which prevents previously

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detected illegal cards from gaining access. However, as indicated by the presence of

the blacklisting operation, the system proposed in Cohen can talk to any smart card that

is not on the blacklist, and is thus susceptible to a pirated card (or a plurality of pirated

cards) that has not yet been blacklisted. Furthermore, the verification process proposed

5   by Cohen is triggered by the broadcast source. Thus, a pirate could simply remove the

verification commands from the broadcast stream thereby circumventing the verification

process altogether. Another practical problem resulting from use of the broadcast

source to trigger the verification process is an architectural one whereby what should be

a local level decision (when and whether to challenge a smart card) is turned into a

10   system level decision. Finally, the verification process in Cohen is not tied to the

transaction between the smart card and the verifier. Thus, a pirate could use a

legitimate card for access authentication, i.e., to authenticate its right to access the

content of the broadcast, and then use a pirated card to avoid being billed for the

access, i.e. to avoid recording that the access was actually made by the legitimate card

15   holder. This type of pirating is referred to herein as an example of a type of attack

known as a conduit attack.

        Another security approach is described in U.S. patent 5,461,675 to Diehl et al,

which proposes to relate data between successive data packets, thus detecting when a

packet has been removed. Particularly, Diehl proposes to inform a legitimate smart

20   card when it is being avoided. However, a pirated card could simply ignore such

information and provide pirated access to the information.

        In yet another approach, proposed in U.S. patent 5,778,068 to Johnson et al, a

determination is made whether a processing device and a user device, which contains a

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storage device, are authorized to operate with each other. The Johnson approach

determines whether a user device, in this case, a device which generally corresponds to

a set type box, is valid by authenticating the user device to a provider device, in this

case, a device which generally corresponds to a backend module. However, this

5   approach does not determine if the provider device is valid, i.e. if the provider device is

authorized to operate with the user device or with a provider device. Accordingly, a

pirate who successfully reverse engineered and modified the provider device could

overcome the security protocols in Johnson, and more importantly, could mass produce

the pirated provider device for distribution to and by users.

10   Another approach is proposed in U.S. patent to Peterson, Jr. Peterson

authorizes access through a smart card which delivers key information to a processor

which allows a playback device to reproduce information from a recording medium. The

system proposed by Peterson uses a public key held at an authorization center and a

private key held by the card. However, there is no pairing operation between the card

15   and the processor, and there is no shared secret key between the card and the

processor. Therefore, if a pirate successfully broke the encryption mechanism he/she

could mass produce and widely distribute pirated cards, causing harm to the information

provider.

Another approach is proposed in U.S. patent 5,448,045 to Clark, which uses a

20   smart card to create a secure boot application on a computer by using the smart card to

verify the executable files that the computer will run. The smart card and the computer

share a secret which is installed by an administrator, and the smart card and the

computer execute an authentication operation. However, once an attacker figures out

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the code, the pirated smart card would be able to authenticate itself. Furthermore, since there is no notion of challenge to the card by the computer, the authentication is replayable. Therefore, a card that is no longer valid may continue to be used.

Finally, another approach, proposed in U.S. patent 5,802,176 to Audebert,

5   controls access to a particular function on a computer by using a renewable card. This is a transaction based system in which the card and the computer negotiate access and a key changes each time access occurs. However, this approach is limited to the particular function which is to be accessed on the computer, and is not useful for a system which deals with may different unpredictable functions/programs such in an

10   information dissemination system, i.e. a system in which each different program (movie, song, article, executable, etc.) would be a different function.

What is needed is a pirate card rejection (PCR) method and system for protecting valuable information; a method and system which is robust, which can be tailored to the needs of a particular information provider, and which overcomes the

15   above noted deficiencies.

Summary And Objects Of The Invention

It is an object of the invention to prevent unauthorized access to information disseminated by an information provider.

20   It is a further object of the invention to prevent a pirate from enabling a large number of persons from obtaining unauthorized access to information from an information provider.

5

It is a further object of the invention to allow the information provider the flexibility of choosing any combination of a plurality of pirate card rejection techniques according to the individual needs of the information provider.

It is a further object of the invention to provide information only through an
5   authorized receiving device and an authorized security device, such as a conditional access module ("CAM").

It is a further object of the invention to provide information only through an authorized non-renewable device and a renewable device.

It is a further object of the invention to cause a non-renewable device to reject a
10   pirated renewable device, such that access to secured information is not obtained.

It is a still further object of the invention to provide a method and apparatus requiring a receiving device and a security device, such as a CAM, to communicate through a shared secret in order for a user to gain access to information.

It is an object to provide a method and apparatus which requires a security
15   device, such as a conditional access module, to be paired with a receiving device and to provide information only through paired receiving and security devices.

In an aspect of the invention, it is an object to prevent an information receiving device from effectively communicating with a CAM with which it is not paired.

In another aspect of the invention, it is yet a further object to provide a method
20   and apparatus wherein a security device can verify the authenticity of the media a receiving device is accessing.

In another aspect of the invention, it is an object to provide a method and apparatus for effectively preventing a pirate from interfering with the communications

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between the receiving device and the security device by requiring the communication to be carried out according to a specified protocol.

In yet another aspect of the invention, it is an object to provide a method and apparatus wherein a receiving device and a security device are required to negotiate a

5   shared secret for communicating with each other.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, as embodied and broadly described herein, an apparatus for practicing the present invention for preventing unauthorized access to information may comprise a renewable device for authorizing the non-renewable device to process the

10   information, the non-renewable device is paired with the renewable device by a shared secret which enables each of the non-renewable device and the renewable device to communicate with the other. The renewable device communicates with the non-renewable device according to a predetermined protocol using the shared secret.

Preferable, the information is encrypted and the non-renewable device includes

15   an output for outputting the information to the renewable device, and the renewable device includes a decryption logic for decrypting the information, and an output for outputting the decrypted information to the non-renewable device.

Typically, the information will comprise a specified program (i.e., data or extendable). It is therefore preferred that at least one of the non-renewable device and

20   renewable device include an access window logic for generating an access time window of a predetermined time duration for the specified program, the time window limiting the time access to the specified program.

It is also preferred that the non-renewable device include a control logic generating a

query message, and an authentication logic for authenticating information contained in

said query message and information contained in a response message using said

shared secret, in order to generate a non-renewable device authentication message.

5   The renewable device preferably includes an authentication logic for authenticating the

information contained in the query message and the information in the response

message using the shared secret, in order to generate a renewable device

authentication message. The renewable device preferably also includes a control logic

operable to generate the response message, and to provide the non-renewable device

10   with the response message. The non-renewable device control logic is preferably

further operable to match the renewable device authentication message with the non-

renewable device authentication message, and to provide the renewable device with the

specified program if the renewable device authentication message matches the non-

renewable device authentication message.

15   Preferably, the renewable device logs access to the information after providing the

response message to the non-renewable device.

Preferably, a freshness generator for generating an arbitrary value is associated

with the non-renewable device.

Typically, the information will be encrypted and the non-renewable device

20   preferably includes a super-encryption logic for super-encrypting the information and the

renewable device preferably includes a super-decryption logic for super-decrypting the

super-encrypted information, and a decryption logic for decrypting the information.

Preferably, the non-renewable device includes a media authentication logic for authenticating a media on which the information to be accessed is carried, and the renewable device also includes a media authentication logic for authenticating the media.

5   In another aspect, the present invention may comprise a method for preventing unauthorized access to information in a system which comprising a non-renewable device having a control logic and a renewable device having a control logic. The method comprising the steps of

pairing a non-renewable device with a renewable device;

10   selectively authenticating message exchanged between the non-renewable device and the renewable device and sending an authenticated message based on selected messages from one of said non-renewable device and said renewable device;

verifying said authenticated message in other of the non-renewable device and said renewable device; and then

15   authorizing access to the information.

Preferably, the step of pairing further comprises

generating an ID value for the non-renewable device;

generating an ID value for the renewable device;

generating at least one certificate based on the ID value for said non-renewable

20   device and the ID value for said renewable device; and

sending said at least one certificate to at least one of the non-renewable and renewable devices.

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The non-renewable device is preferably a source device, such as that commonly associated with a set top box. The non-renewable device may also include a sink device, typically the device where the information is to be consumed.

The system may also include a backend system and the step of pairing will

5 preferably further comprises

generating an ID value for the non-renewable device;

determining secret information of the non-renewable device in the backend system based on the ID value for the non-renewable device; and

sending the secret information to the renewable device.

10 Preferably each of the non-renewable device and the renewable includes an authentication logic, and the step of selectively authenticating messages further comprise

sending a query message form the non-renewable device to the renewable device;

15 authenticating the information contained in the query message and information in a response message using a shared secret, thereby generating a renewable device authentication message, the response message being generated by the renewable device;

authenticating information contained in the query message and information

20 contained in the response message using the shared secret, thereby generating a non-renewable device authentication message;

verifying that the renewable device authentication message matches the non-renewable device authentication message.

10

In another aspect, the present invention provides a method of preventing unauthorized access to information in a system comprising a non-renewable device having a control logic and a renewable device having a control logic. The method comprises

5   sending a media query message from the renewable device to the non-renewable device;

authenticating information contained in the media query message and information contained in a media response message generated at the non-renewable device, thereby generating a non-renewable device media authenticated message;

10   sending the media response message and the non-renewable device media authenticated message to the renewable device;

authenticating the information contained in the media response message and information contained in the media query message at the renewable device, thereby generating renewable device media authenticated message; and

15   verifying the non-renewable device media authenticated message with the renewable device media authenticated message at the renewable device.

Preferably, the renewable device includes a counter for generating a renewable device count value which is included in the media query message and the method further comprises:

20   incrementing the renewable device count value at the non-renewable device; and

incrementing the renewable device count value at the renewable device the verification step is successful.

Preferably the renewable device may include a random number generator for generating a renewable device random value which is included in said media query message, and the method for further comprises

incrementing the renewable device random value at the non-renewable device;

5   and

incrementing the renewable device random value at the renewable device if the verification step is successful.

In yet another aspect, the present invention provides a method of preventing unauthorized access to information in a system comprising a non-renewable device and

10   a renewable device. The method comprises the

(a)   sending a seed negotiation request from the non-renewable device to the renewable device;

(b)   sending a challenge and a status query from the renewable device to the non-renewable device;

15   (c)   determining if the non-renewable device and the renewable device are in cryptographic sync; and

(d)   returning to step (a) if the non-renewable device and renewable device are not in cryptographic sync.

Preferably, the method further comprising the steps of:

20   (e)   determining if the non-renewable device and the renewable device are in packet sync; and

(f)   providing information to the renewable device in discrete indexed packets when the non-renewable and renewable devices are in packet sync.

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Preferably, the information is provided to the renewable device within a predetermined access windo9w, and the step of providing information further comprises verifying a portion of the information and receipt of said information by the renewable device within the predetermined access window.

5   Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the

10   appended claims.

Brief Description Of The Drawings

The accompanying drawing, which are incorporated in and form a part of the specification, illustrate several embodiments of the present invention and, together with

15   the description, serve to explain the principles of the invention.

Figure 1 is a block diagram of an embodiment of the present invention.

Figure 2 is a flow diagram depicting an embodiment of a unidirectional pairing operation between a Source and an authenticated conditional access module ("CAM") according to the invention.

20   Figure 3 is a flow diagram depicting another embodiment of a unidirectional pairing operation between a Source and a CAM.

Figure 4 is a flow diagram depicting an embodiment of a unidirectional pairing operation between a CAM and an authenticated Sink.

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Figure 5 is a flow diagram depicting an embodiment of a bi-directional pairing operation between a Source and a CAM with a direct shared secret value.

Figure 6 is a flow diagram depicting an embodiment of a bi-directional pairing operation between a Source and a CAM with a direct shared secret value.

5   Figure 7 is a diagram depicting an embodiment of a bi-directional pairing operation between a Source and a CAM with a direct shared secret value.

Figure 8 is a diagram depicting an embodiment of a bi-directional pairing operation between a CAM and a Sink with a direct shared secret value.

Figure 9 is a diagram depicting yet an embodiment of a bi-directional pairing

10   operation between a CAM and a Sink with a direct shared secret value.

Figure 10 is a block diagram of a first embodiment of a title-based pirate card rejection ("PCR") architecture according to the present invention.

Figure 11 is a flow diagram illustrating the operation of a title-based PCR protocol according to the invention.

15   Figure 12 is a flow diagram illustrating another embodiment of a title-based PCR protocol with a window query operation.

Figure 13 is a block diagram depicting another embodiment of the invention having a metered, title-based PCR architecture.

Figure 14 is a flow diagram illustrating the operation of a metered, title-based

20   PCR protocol according to the invention.

Figure 15 is a flow diagram illustrating the operation of a metered, title-based PCR protocol with credit request according to the invention.

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Figure 16 is a block diagram depicting another embodiment of the invention

having a metered, title-based pirate card rejection (PCR) architecture with nonvolatile

memory (NVR) in the Source.

Figure 17 is a block diagram depicting a another embodiment of the invention

5   having a combined Super-encryption/re-encryption and title-based.

Figure 18 is a flow diagram illustrating the operation of a Super-encryption and

re-encryption PCR protocol.

Figure 19 is a block diagram depicting a another embodiment of the invention

having a Combined Super-encryption/re-encryption PCR architecture.

10   Figure 20 is a flow diagram illustrating the operation of a Combined Super-

encryption/re-encryption PCR protocol.

Figure 21 is a block diagram depicting another embodiment of the invention

having an authenticating media Source architecture.

Figure 22 is a flow diagram illustrating an operation of an authenticating media

15   Source protocol according to the invention.

Figure 23 is a flow diagram illustrating another operation of an authenticating

media Source protocol according to the invention.

Figure 24 is a block diagram depicting another embodiment of the invention

having a Combined Super-encryption/re-encryption title-based PCR and media

20   authentication architecture.

Figure 25 is a flow diagram illustrating an operation of a Combined Super-

encryption/re-encryption, title-based PCR and media authentication protocol according

to the invention.

15

Figure 26 is a block diagram depicting another embodiment of the invention

having a date-based ("BBRAM") PCR having a NVM on a set top box ("STB") and a

battery backup RAM on a CAM architecture.

Figure 27 is a flow diagram illustrating an operation of a data based PCR

5   protocol with NVM on a STB and a BBRAM on a CAM.

In the various figures, identical or similar elements, structures and operations are

similarly numbered. Any differences between similarly numbered element, structures

and operations in the various figures will be apparent to the artisan from the figures or

from the following description.

10

Detailed Description Of The Invention

Reference will now be made in detail to the presently preferred embodiments of

the invention, examples of which are illustrated in the accompanying drawings.

Figure 1 is a simplified block diagram of an embodiment of the depicting an

15   exemplary Pirate Card Rejection ("PCR") system according to the present invention. As

shown in Figure 1 a conditional access module ("CAM") **400** conditionally authorizes

access to information from a backend system **700** through a set top box **100** which

include a source **200** and a sink **300**. The source **200** may receive the information from

almost any system or source such as, for example, a data stream, a broadcast stream,

20   or a readable storage medium such as an optical readable and/or recordable disc, a

magnetic disc or a tape. An example of an optical readable and/or recordable disc

includes, but is not limited to, a CD or DVD disc which contains digital audio and video

information such as movies and/or other data and executables. As used herein, the

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term "information" is intended to broadly refer to content data, such as audio and or video data, as well as other types of data and executables from any source. Similarly, a specific program or title within the information may include content data, such as who and/or video, data, as well as other types of data and executables from any service.

5   The source **200** may include conventional circuitry known to those of skill in the art for receiving a data stream, a broadcast stream, and/or conventional circuitry to retrieve information from an optical readable and/or recordable disc or a magnetic disc or tape by using any one of a variety of techniques well known to one of ordinary skill in the art, examples of which are illustrated in U.S. patent 5,481,609 to Cohen et al and

10   U.S. patent 5,440,631 to Akiyama et al.

The sink **300** is operable to transform the data stream into a visually and/or audio perceptible form, so that it may be displayed using a variety of video and/or audio display devices as are known in the art or to execute an executable or otherwise process data. In the movie example, the sink **300** contains conventional circuitry,

15   known to those skilled in the art, for converting information into video and audio information which may be displayed on a video and/or audio display system. For other applications, such as accessing executables, the sink **300** may, for example, be (or be incorporated into) a general purpose computing device. Although the source **200** and the sink **300** are shown as separate devices in Figure 1, they may alternatively be

20   integrated into one device. Also, although the Source **200** and the Sink **300** are shown in Figure 1 as part of a set top box ("STB") **100**, one or both may be separate from the STB.

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The CAM **400** preferably comprises a relatively inexpensive module having decryption and advantageously logging capabilities. The CAM **400** may decrypt the content of the information (movies, music, articles, executables, etc.), or the CAM **400** may decrypt a key which allows a device in the set top box **100**, which preferably

5   includes the source **200** or the sink **300**, to decrypt the content of the information. Alternatively, the CAM **400** may authorize the source **200** and sink **300** to access the information. The CAM **400** may, for example, include a series of pins **402** which can be plugged into a receptacle **102** mounted on the set top box **100**. In the context of the present invention, the CAM **400** is considered to be an example of a renewable security

10   device. Although Figure 1 shows CAM **400** to be outside of the set top box **100**, it may also be contained within the set top box **100** which would require the set top box **100** to be opened to remove the CAM **400**. The renewal of the CAM **400** is preferably done with the authorization of the information provider, and may be done on an individual need basis to replace a defective CAM or a pirated CAM, or may be done periodically to

15   further guard against pirating of the CAM **400**. Accordingly, a PCR system according to the invention is advantageously designed to allow the customer to substitute CAMs for the legitimate purpose of responding to CAM failure and to allow for the issuance and insertion of replacement CAMs for reasons of security and/or enhanced or improved operation.

20   The CAM **400** may contain a microprocessor **404** or the like that enables it to perform decryption and logging (e.g., billing, access authorization access recordation and management of other transactional information), and in some embodiments, to perform re-encryption as well. The CAM **400** preferably uses some combination of local

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non-volatile memory **406** and (on-line or off-line) services for connecting to remote

nodes in order to reliably accomplish logging. In some cases, the CAM **400** must

retrieve such information from either local memory **406** or remote archives for use by

the non-renewable playback device, i.e., the set top box **100**. The frequency of such

5   reads and/or writes may determine the efficacy of using local non-volatile memory vs.

remote archives accessed through modems or other means. As alluded to above, the

CAM **400** may make use of local storage elements **406** which are located onboard the

CAM **400** or associated storage components. For example, located within the set top

box **100**, there are preferably storage elements **202** or **302** which may be part of the

10   source **200** or the sink **300** respectively, or mounted on a separate board or module of

its own.

The backend **700**, which may include a conditional access system, bills the

information user for accessing the information or may process the log in other ways.

The backend **700** may or may not provide the information, such as a movie, directly to

15   the set box **100**. For example, the information user may obtain the movie from a local

source, such as a DVD, which can only be accessed after the access is logged. Such a

system is disclosed in commonly assigned U.S. patent 5,822,291 which is hereby

incorporated by reference.

Assuming that at least some part of the source content is protected by

20   encryption, the corresponding decryption procedure is achievable through use of

secret(s) legitimately made available to CAM **400** which operate in compliance with the

backend **700**. Preferably, the CAM **400** is a renewable device which is controlled by the

information provider or by a certification authority, either or both of which may be part of

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the backend **700**. For example, a certification authority may be an entity which is

independent of the backend **700** and which certifies keys that are used on the CAM

400. Alternatively, the certification authority may be the same entity as the backend

700 or be incorporated into the backend **700**. An example of the operation of a

5   certification authority may be found in CCITT, Recommendation X.509 (1989).

The set top box **100** is preferably a non-renewable device that is owned or

leased by the customer of the information provider.

Since a pirate can sell competing (pirated) components at a cost lower than the

value of the information sold by the legitimate information provider, there is a need for

10   technology that causes the non-renewable component (i.e., the set top box **100**) to

reject the pirated renewable component (i.e., the CAM **400**). Particularly, pirate card

rejection (PCR) is most effective when deployed in connection with a backend system

700 where the pirate must both compromise the CAM **400**, thereby learning the

universal secrets of the CAM **400**, and compromise the information receiving device,

15   e.g., the set top box **100**, perhaps by altering legitimate broadcast receivers or

legitimate playback devices. If a pirate is not willing (or is not efficiently able) to

compromise individual CAMs to learn individual secrets or modify functionality such as

logging of play on individual CAMs, then the access system will remain secure. In other

words, PCR is most effective if the easier of the two possible circumvention methods is

20   prohibitive from an economic standpoint. Additionally, even if a pirate manages to build

non-compliant set top box devices, security is conditioned on the assumption that he

cannot do so on a large scale, not only because such devices are expensive to build,

distribute, and support, but also because profit margins on even legitimate set top box

20

devices are low. Accordingly, a rational, economically motivated pirate would prefer to build pirated CAMs than pirated playback devices. Thus the real threat of attack to the information provider is from pirated CAMs.

In the case of *explicit* PCR, the set top box **100** will reject communication from CAMs with which they are not authorized to communicate. Explicit PCR enables the devices to detect attempts to bypass the security provided by the CAM **400**, and to reject communications and authorizations from pirated CAMs.

In the case of *implicit* PCR, if there is an attempt to by pass the CAM **400** the devices will fail to attain an acceptable level of service in terms of uninterrupted and uncorrupted presentation of the source material, because of a breakdown or disruption in effective communications.

In order to be an effective pirate card rejection module, a PCR system should effectively rebuff various types of attack. Namely, an effective PCR system should preferably counter attacks based on the use of a legitimate set top box device and a pirated CAM, a legitimate set top box device with a pirated CAM hosting a legitimate CAM (the *conduit* attack), and a pirated set top box device and a legitimate CAM. The delineation of these scenarios is independent of whether the set top box device can authenticate itself. For example, if a pirated version of a set top box device that authenticates itself can use a legitimate CAM for free access to information, security may be compromised. Additionally, in the conduit attack, a legitimate CAM is used to enable the legitimate device to generate content bits, while the pirated CAM is used to decrypt those content bits. Another attack is eavesdropping on the stream the legitimate set top box produces, or the stream that the CAM returns to the set top box.

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In accordance with an aspect of the invention, the efficacy of PCR and play-media source authentication is preferably enhanced through the utilization of robust device pairing protocols. Interface protection protocols may also play a role. Individualization, as explained below, may support the security attributes of such

5   protocols. It will be understood by those of skill in the art that a PCR system according to the present invention may include any combination of pairing protocols, PCR protocols, interface protection protocols, and anti-piracy techniques. Accordingly, any number of combinations of multi-layer protocols can be used for customized security. For example, one such multi-layer protocol that may be used is an undirectional pairing

10   of a source and an authenticate CAM operation with a title-based PCR protocol. Particularly, the selection of the combination will depend on the business goals of the information provider. This is a significant improvement over the prior art because many prior art devices rely on system architecture for security and do not provide flexibility in choosing an architecture consistent with a desired business plan.

15   The pairing protocols and the PCR protocols described below rebuff attacks involving a pirated set top box or a pirated CAM used separately, as well as the conduit attack and the eavesdropping attack. The detection of piracy, which may be characterized by local replay of information generated by the set top box **100**, is within the scope of the invention. Additionally, real time authentication of the set top box **100**

20   the CAM **400** and the media on which the information is provided prevents the user from accessing information on currently authorized media.

Each CAM **400** is preferably individualized and paired with a particular set top box **100**. Individualization refers to the fact that each CAM (or relatively small subset of

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CAMs) contains a secret which is difficult to derive through knowledge of the secrets of

other CAMs. As should be apparent, it is substantially easier for the conditional access

provider to individualize a CAM than it is for the pirate to obtain those individualized

secrets from the CAM. Each CAM **400** also preferably contains a universal key or

5   series of keys which may be used for conditional access to information.

The universality aspect refers to the fact that efficient broad case distribution

mechanisms may severely limit the number of versions of content which are broadcast

at any one time or otherwise made available.

10   **PAIRING**

The requirement of pairing prevents the pirate who successfully reverse

engineers a legitimate CAM from mass producing a derivative CAM which uses can be

with the source devices of other users. Specifically, it is contemplated that a derivative

CAM will not successfully be able to be paired with source devices other than those with

15   which the original CAM is authorized to be paired. The backend system **700** may issue

a pairing by which associates a source **200** with a downstream CAM **400**. Similarly, a

pairing may be issued which associates a CAM **400** with a downstream sink **300**.

Pairings may be unidirectional in that only one of the two entities, for example the

downstream entity, is an authenticated entity, (i.e., an entity that will consequently be

20   able to authenticate communications to the other entity as having originated with it) as

may be verifiable by the other (unauthenticated) entity. Such a pairing alternatively or

additionally allows encrypted communications to be directed to the authenticated entity.

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A unidirectional pairing may be established by means of presenting an authenticated public key to an entity which enables, and thus effectively authorizes, that entity to successfully communicate with an entity in possession of the corresponding private key. The authenticated public key is presented in such a way that the association of the

5   public key with the entity authorized to communicate by means of that public key is explicitly authenticated.

One means of establishing a bi-directional pairing is through establishment of two unidirectional pairings.

One goal of pairing is to allow the two entities to establish a shared secret value.

10   This may be accomplished by using the authenticated public key and corresponding private key of the authenticated entity. If the establishment of the shared secret value is based on a single unidirectional pairing, the unauthenticated entity contributes a public key for which it possesses the corresponding private key. This key pair may be generated on the device or may be established during or related to the device

15   manufacturing process.

In the case of bi-directional pairing both entities may present authenticated public keys.

In order to establish the shared secret value, the two entities may use a function f, such as that taught in US Patent No. 4,200,770, where f(PUBKEY entity 1,

20   PRIVKEYentity 2) = f(PUBKEYentity 2, PRIVKEYentity 1). In that case, each of the entities, for example entity 1 and entity 2, derive the shared secret value by applying the function f to the other entity's public key and its own private key. A shared secret value may alternatively be established by using the authenticated public key in an encryption

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algorithm (see e.g., U.S. Patent No. 4,405,829 or *A Public Key Crypitosystem And A Signature Scheme Based On Discrete Logarithms;* T. El Gamal, Advances In Cryptology (1985)), where the shared secret value may be chosen directly by the entity that does the encryption. Alternatively, bi-directional pairings may result directly in the

5   establishment of a shared secret value.

In order to preserve the desired effect of pairing, the backend **700** or some other trusted authority may determine or verify the extent to which nominally distinct authenticated entities are associated with common public keys.

An entity may play a role in policing itself in that either before or after being

10   authorized to communicate with a particular entity, it limits the number of apparently distinct entities with which it will communicate.

Pairing revocation/deauthorization:

In accordance with an aspect of the invention, digitally-signed lists and/or specifically targeted deauthorization messages may be issued in order to effectively

15   remove offending parties from the system. Specifically targeted messages may be encrypted and/or authenticated uniquely for a given source **200**, sink **300** or CAM **400** device. As a form of passive deauthorization, pairings may expire as discernible, for example, by checking a pairing expiration date against local date information available to the appropriately configured device. As further explained below, the pairing

20   expiration may be indicated by certificates, if appropriate.

The system may support delayed bindings for which one or more aspects of the pairing are not immediately verifiable. The pairing may be used temporarily, where the

pairing is later confirmed or rejected (i.e., revoked or deauthorized) by the appropriate authority.

Some of the embodiments of pairing protocols depicted in the following illustrations make use of digital certificates which link information associated with a single entity, as denoted by the Entity-Certify (information) operation, or which cross-certify by linking information associated with distinct entities, as denoted by the Cross-Certify (information) operation. The result of these operations are an Entity-Certificate and Cross-Certificate, respectively.

The certificates are generated using knowledge of private signature keys such that the associated public verification keys appear in a chain of acceptable keys as held by the verifying entity. The chaining of keys may itself be established by use of certificates. The certificates in the following protocols are to be understood as including signatures on text, as well as the text itself if necessary. In some cases, parts of the text may separately be known by or separately delivered to the verifying party. Certificates may also include an indication of which public signature verification key should be used to verify the certificate. Cross Certificates may be generated by the conditional access system backend **700**. Entity-Certificates may be generated by the conditional access system backend **700** or by an authority trusted by the backend to perform this function.

As used in the protocols illustrated in the figures described below, if an ID pertains to an unauthenticated entity, the ID may be generated randomly or pseudo-randomly during the pairing operation.

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The public key of the entity to be authenticated, if needed by the conditional access system backend 700, may be addressable by the backend 700 by using the entity ID or may be understood to be communicated to the backend 700 (preferably securely) as part of the pairing operation. The private key of the entity to be

5   authenticated may in some instances be communicated (preferably securely) to the entity as part of the pairing operation. This latter technique allows the backend 700 to dynamically allocate shared public key values to designated groups of entities.

Either of the two entities in a pairing may reject the pairing on the basis of information received from the other entity or from the backend 700.

10   An exemplary architecture for performing the operation of the following pairing protocols is shown in Figure 17. Figures 2 through 9 illustrate the operation of the protocols by showing the parallel processing of the source 200, the CAM 400 and the backend 700 and their respective interaction. As will be understood by one of skill in the art, the protocols illustrated are exemplary and the sequence of some steps or the

15   communication paths may be altered without departing from the spirit or scope of the invention. In the figures, parallel lines surrounding a flow arrow, for example between the source 200, the CAM 400, and the backend 700 respectively, (see, e.g., Fig. 2, step S205, step S213, step S207, step S215 and step S210) is intended to illustrate a synchronizing operation wherein the receiving device must receive the message shown

20   by the flow arrow before it may proceed.

Notationally, when shown between arguments of subroutines, commas denote concatenation of data streams. The term "message" may itself be a concatenation of

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various sub-messages, and the symbol ⊕ denotes bit-wise exclusive-or of bitstreams of like length.

Unidirectional Pairing of A Source and An Authenticated CAM

5   Reference will now be made to Figures 2 and 3 for a discussion of unidirectional pairing protocols for the source **200** and an authenticated CAM **400**. In the various protocol diagrams, similar steps within the various protocols are labeled with similar reference numerals for ease of understanding. However, it should be understood that the actual implementation of those steps may be the same or different in practice.

10   As shown in Figure 2, the source **200** sends a source ID to the CAM **400** (**S201**). After receiving the source ID (**S204**), the CAM **400** sends a CAM ID and the source ID to the backend **700** (**S205**). After receiving the source ID, the backend **700** generates a Cross-Certificate and sends it to the CAM **400** (**S211, S212, S213**), i.e. the backend **700** generates the value Cross-Certify(CAM_ID, Source_ID). The CAM **400** then sends the

15   Cross-Certificate to source **200** (**S202**). The CAM **400** determines if there is a local Entity-Certificate on the CAM **400** (**S208**). Namely, the value Entity-Certify(CAM_ID, CAM_Pub) where CAM_Pub is the public key of the CAM. If the determination is YES, then the CAM **400** sends the local Entity-Certificate of the CAM **400** to the source **200**, and the CAM **400** is paired with the source **200** (**S210, S203**). If the determination is

20   NO, then the CAM **400** receives a Local Entity-Certificate from the backend **700**, if the backend **700** has a Local Entity-Certificate for the CAM **400** (**S209, S215, S214**). The CAM **400** then sends the local Entity-Certificate received from the backend **700** to the source **200**, and the CAM **400** is paired with the source **200** (**S210, S203**).

Alternatively, the above certificates may take the value of Cross-Certify(Entity-Certify(CAM_ID, CAM_Pub), Source_ID) or the value Cross-Certify (CAM_Pub, Source ID).

In the process of verifying the certificate(s), the source **200** checks, in particular,

5   that the Cross-Certificate was computed using its specific source ID.

In the present embodiment, it is assumed that the CAM **400** is in possession of the private key, CAM_Priv, independently of this protocol. The Entity-Certificate, if required, is sent (once) by the CAM **400** to the source **200** (**S210**), whether or not the backend **700** can access this certificate and consequently transmit it to the CAM **400**.

10   When the CAM **400** checks for a local Entity-Certificate, it may check if its version of the Entity-Certificate is currently valid. If not, it can use the version of the Entity-Certificate it receives from the backend **100**, if any.

In the alternative embodiment, shown in Figure 3, the source **200** sends a source ID to the CAM **400** (**S301**). After receiving the source ID (**S303**), the CAM **400** sends a

15   CAM ID and the source ID to the backend **700** (**S304**, **S308**). The backend **700** generates a CAM private key, CAM_Priv, and a CAM public key, CAM_Pub, and generates a Cross-Certificate, i.e. the backend generates a value Cross-Certify(CAM_Pub, Source_ID) (**S309**, **S310**). Next, the backend **700** sends the CAM private key, CAM_Priv, to the CAM **400** through a secure transmission (**S311**, **S305**).

20   The backend **700** also sends the Cross-Certificate to the CAM **400**, which then sends the Cross-Certificate to source **200** (**S312**, **S306**, **S307**, **S302**). The CAM **400** is now paired with the source **200**.

In the embodiment of Figure 3, it may be assumed that the CAM private key, CAM_Priv, is not held at the CAM **400** independently of this protocol. It may further be assumed that a secure channel exists to confidentially transmit the CAM private key, CAM_Priv, from the backend **700** to the CAM **400**.

5

Unidirectional Pairing of A CAM and An Authenticated Sink

Reference will now be made to Figures 4 and 5 for a discussion of unidirectional pairing protocols for the CAM **400** and an authenticated sink **300**.

As shown in Figure 4, the sink **300** sends a sink ID to the CAM **400** (**S401**). After receiving the sink ID (**S404**), the CAM **400** sends a CAM ID and the sink ID to the backend **700** (**S405, 410**). The sink **300** determines if there is a local Entity-Certificate (**S402**). If the determination is YES, the sink **300** sends the local Entity-Certificate of the sink **300** to the CAM **400** (**S403, S406**), i.e., the value Entity-Certify(Sink_ID, Sink_Pub) where Sink_Pub is the public key of the Sink. If the determination is NO, the protocol ends. The CAM **400**, then sends the local Entity-Certificate of the sink **300** to the backend **700** (**S407, S411**). The backend **700** determines whether it holds a local Entity-Certificate for the sink **300**, and if it does, then whether the local Entity-Certificate held by the backend **700** supersedes the local Entity-Certificate held by the sink **300** (**S412, S413**). If the determination in both steps **S412** and **S413** is YES, then the backend **700** sends the CAM **400** the local Entity-Certificate for the sink **300** held by the backend **700** (**S414, S408**). Next, the backend **700** generates a Cross-Certificate (**S415**), i.e. the backend generates the value Cross-Certify(Sink_ID, CAM_ID). Then

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the backend **700** sends the Cross-Certificate to the CAM **400** (**S416**, **S409**), causing the CAM **400** to be paired with the sink **300**.

If the CAM **400** receives Entity-Certificate from sink **300** in step **S406**, Entity-Certificate information may include version number, or expiration date, or issue date,

5   etc. Furthermore, in step **S414**, either entity certificates or the sink public key, Sink_Pub, is sent, but not both. In the event Sink_Pub is sent, it should preferably be transmitted securely to the CAM **400** so as to avoid undetected substitution. Additionally, if there is an Entity-Certificate (corresponding to the specific Sink_ID) held at the backend **700**, and it supersedes the version received by the CAM **400** from the

10   sink **300** (as based on the Entity-Certificate Information), this Entity-Certificate, namely the value Entity-Certify(Sink_ID, Sink_Pub), in included in the transmission in step **S414**. If no Entity-Certificate Information is received by the backend **700**, the local Entity-Certificate (if any) would be sent to the CAM **400**.

Alternatively, the above certificates may be of the value Cross-Certify(Entity-

15   Certify(Sink_ID, Sink_Pub), CAM_ID), or of the Cross-Certify(Sink_Pub, CAM_ID).

In the process of verifying the certificate(s), the CAM **400** checks, in particular, that the Cross-Certificate was computed using its specific CAM_ID. The CAM **400** uses the most current of the Entity-Certificate (if any) as received from the sink **300** and/or the backend **700**.

20   In the alternative embodiment shown in Figure 5, the sink **300** sends a sink ID to the CAM **400** (**S51**). After receiving the sink ID (**S502**), the CAM **400** sends a CAM ID and the sink ID to the backend **700** (**S503**, **S506**). The backend **700** uses the sink ID to

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look up a public key Sink_Pub for the sink **300** (**S507**). Then backend **700** sends

Sink_Pub to the CAM **400**, and CAM **400** becomes paired with sink **300** (**S508, S504**).

Bi-directional Pairing of Source and CAM with Direct Shared Secret Value

5   In this and the following bi-directional protocol, the shared secret value is sent to

the CAM **400** from the backend **700**, as an explicit part of the pairing operation. This

should be preferably done via a secure means of communication between the backend

700 and the CAM **400**. If not already possessed by the other entity independently of the

pairing protocol, this secret should preferably be communicated to the other entity from

10   the backend **700** through the CAM **400** in such a way as to preserve its confidentiality

over the channel between the CAM **400** and the other entity. This may be done, for

example, by an encryption procedure where the corresponding decryption procedure is

known to the other entity. We denote the secured version of the secret by the value

(Source_Secret)$_{SOURCE}$ and the value (Sink_Secret)$_{SINK}$, respectively. The source **200**,

15   or sink **300**, may not know its secret independently of the pairing protocol, because it

may be determined dynamically by the backend **700**. This technique may be invoked if,

for example, it is deemed advantageous that two or more CAMs which are authorized to

communicate with a single source (or sink) are forced to maintain distinct cryptographic

identities.

20   As shown in Figure 6, the source **200** sends a source ID to the CAM **400**, which

sends the source ID and a CAM ID to the backend **700** (**S601, S602, S603, S605**). The

backend **700** uses the source ID to look up a source secret, Source_Secret, (**S606**)

which is sent via a secure transmission to the CAM **400** (**S607, S604**). Although not

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illustrated in Fig. 6, if the Source_Secret is not known to the source **200** then the backend **700** sends the value (Source_Secret)$_{SOURCE}$ to the CAM **400**. In either event, CAM **400** becomes paired with the source **200**.

In an alternative embodiment, depicted in Fig. 7, the source **200** sends a source ID to the CAM **400**, which sends the source ID and a CAM ID to the backend **700** (**S701, S703, S704, S708**). The backend **700** generates a source secret, Source_Secret, (**S709**), and sends the value Source_Secret to the CAM **400** through a secured transmission (**S710, S705**). Then the backend **700** generates the value (Source_Secret)$_{SOURCE}$ (**S711**). In this embodiment it is assumed that the source secret is not known to the source beforehand. Next, the backend **700** sends (Source_Secret)$_{SOURCE}$ to the CAM **400**, which sends it to the source **200** (**S712, S706, S707, S702**). Thus, the CAM **400** becomes paired with the source **200**.

Bi-directional Pairing of CAM and Sink with Direct Shared Secret Value

Reference will now be made to Figures 8 and 9 for a discussion of bi-directional pairing of the CAM **400** and the sink **300** with direct shared secret value.

As shown in Figure 8, the source **300** sends a sink ID to the CAM **400**, which sends the sink ID and a CAM ID to the backend **700** (**S801, S802, S803, S805**). The backend **700** uses the sink ID to look up a sink secret, Sink_Secret, (**S806**) which is sent via a secure transmission to the CAM **400** (**S807, S804**). Although not illustrated in Fig. 8, if the Sink_Secret is not known to the sink **200** then the backend **700** sends the value (Sink_Secret)$_{Sink}$ to the CAM **400**. In either event, CAM **400** becomes paired with the sink **300**.

In an alternative embodiment depicted in Figure 9, the sink **300** sends a sink ID to the CAM **400**, which sends the sink ID and a CAM ID to the backend **700** (**S901**, **S903, S904, S908**). The backend **700** generates a sink secret, Sink_Secret, (**S909**), and sends Sink_Secret to the CAM **400** through a secured transmission (**S910, S905**).

5   Then the backend **700** generates the value (Sink_Secret)$_{Sink}$ (**S911**). In this embodiment it is assumed that the source secret is not known to the source beforehand. Next, the backend **700** sends the value (Sink_Secret)$_{Sink}$ to the CAM **400**, which sends it to the sink **300** (**S912, S906, S907, S902**). Thus, the CAM **400** becomes paired with the sink **300**.

10

One-Way Hash Function (Hash)

A one-way hash function is a function which takes an input of potentially arbitrary length (length in, for example, bits) and maps the input into an output of some fixed prescribed length, where the outputs are denoted as hash words or hash values. The

15   "one-way" aspect of the function refers to its intended security properties with respect to the computational difficulty of inversion. The function SHA-1, as defined in FIPS 180-1, is a commonly known example of a hash function. See also On the Security of Compressed Encodings; Selim G. Akl; Advances In Cryptology (Proceedings of Crypto 83) (1983) for background information.

20

Key Derivation Function (KDF)

A shared secret value, however established between two entities, may be expanded by iteratively applying a key derivation function. The key derivation function

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may prescribe the length of the shared secret value. If the process, such as Diffie-Hellman, which is used to generate the original, i.e., first, shared secret value, results in values of length different than that prescribed by the key derivation function, both entities can independently derive from the first value a second shared secret value of

5   the prescribed length. The authentication of the shared secret value may be addressed by means of pairing.

The inputs to the KDF include, in particular, the shared secret value. The other input, denoted as the KDF variable, is either a counter which is incremented between applications of the KDF or a random or pseudorandom value which preferably is unlikely

10   to be reused during subsequent applications of the KDF. The output is a hash word which may be considered to be a Key, or a multiplicity of Keys of potentially different length. The Keys may subsequently be used in a bulk encryption algorithm such as the Data Encryption Standard. The Keys may also be used as inputs to subroutines such as Authenticate and Encrypt defined below. The input shared secret value to the KDF

15   may in some instances be held constant. Alternatively, the input shared secret value may itself be refreshed by, for example, periodically replacing it with new values which may be generated by one of the two entities, preferably using a random or pseudo-random number generation process. The new input shared secret value may be transmitted from the originating entity to the other entity by using the Authenticate and

20   Encrypt subroutines defined below, where the Keys used as an input to the Authenticate and Encrypt subroutines are generated using KDF with the current input shared secret value. In the following subroutine definitions, the shared secret value may be suppressed and therefore does not explicitly appear in the subroutine argument list.

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KDF(KDF variable) = Hash(KDF variable, shared secret value, KDF variable)

Command Authentication Function (Authenticate)

Authenticate may be used to authenticate commands of arbitrary length. It is similar in function to HMAC, see Keying Hash Functions For Message Authentication; M. Bellare

5   et al, Advances In Cryptology (Crypto '96) (1996) which uses nested Hash operations.

Authenticate(KDF variable, message) = Hash96(message, Key) $\oplus$ Key',

where Hash96 denotes the 96 most significant bits of the hash word Hash(message, Key), and Key and Key' result from the execution of KDF with input KDF variable. For

10   example, if the function SHA-1 is used as the Hash in KDF, the derived Key may be the first 64 bits and Key' may be 96 bits in length. More specifically, Key equals the 64 least significant bits of KDF(KDF variable), and Key equals the 96 most significant bits of KDF(KDF variable).

Since the message cannot be computed from the result of the Authenticate

15   function, the message may be sent separately either as plain text or encrypted, using, for example, Encrypt, as defined below.

Encrypt, Decrypt, and Confirm

In this example the KDF variable is suppressed. The KDF variable value(s)

20   needed to generate the Key values are assumed to be known or negotiated between the two entities. The following definitions apply:

Encrypt(plaintext message) = plaintext message $\oplus$ Key = ciphertext message

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Decrypt(ciphertext message) = ciphertext message $\oplus$ Key = plaintext message

Confirm(received ciphertext message) is true if and only if Encrypt(local plaintext message) matches the received ciphertext message. Confirm may be used by the receiver entity as assurance that the transmitter entity is in possession of knowledge of the plaintext value. The security of this function may be undermined if an adversary can somehow surmise the plaintext value. Confirm may actually be applied where Hash(plaintext) is used instead of plaintext message itself.

Authentication where the message being confirmed cannot be altered without being detected by the recipient.

Pirate Card Rejection (PCR) Protocols

These protocols use the result of the pairing operation, from which the source 300 and the CAM 400 will share a secret. This secret authenticates (either explicitly or implicitly) the CAM 400 to the source 300. In the case where the CAM 400 and sink 300 are paired, they share another secret which authenticates the sink 300 to the CAM 400.

The operating environment of the protocols preferably includes the following states:

1) Set-up information access: the prerequisite to establishing "play";

2) Information access: the state that "play" invokes;

3)   End information access: the positive action that terminates "play." Information

may not be subsequently accessed without setting-up information access again;

4)   Clean-up information access: associated with "end information access," the

handling of actions (if any) which follow the suspension or termination of play. If this

5   occurs, it precedes resumed "set-up information access."

Title-Based PCR

In the Title-Based PCR embodiment, the customer access by a customer to a

timed window of information is logged, and the customer is then allowed access to the

10   information during that window. The protocol is appropriate for time windows that are

much longer than the information (e.g., a two day movie rental).

In this embodiment, as shown in Figure 10, the source **200** preferably contains a

information receiving/generating device **204**, a freshness generator **206**, source control

logic **208**, authentication logic **210**, and access window logic **212**. The freshness

15   generator produces an arbitrary value. The freshness generator may, for example, be a

counter which produces a count value or a random number generator which produces a

random number, wherein said counter may count either up or down and/or by any

incremental value. Additionally, CAM **400** preferably contains CA (conditional access)

decryption logic **408**, a timer **410**, CAM control logic **412**, authentification logic **414** and

20   an access window **416**. The access window logic **212** and **416**, in the source **200** and

CAM **400** respectively, set a limit on the length of time a user is allowed access to a

specified program. The operation of the embodiment of Figure 10 is illustrated in the

flow diagram of Figures 11 and 12. It should be understood by those of skill in the art

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that the protocol shown Figures 11 and 12 are performed by the source control logic
208 and the CAM control logic **412** respectively.

As shown Figure 11, the source **200** provides the CAM **400** with a message
including a counter value from the freshness generator **206** and the title of the program

5   to be accessed from the information receiving/generating device **204** (**S1101**). The
counter value used is different from counter values of previous messages. For
example, the counter may be a random number from a random number generator,
chosen anew at each iteration of the protocol, or it may be a counter stored in non-
volatile memory (NVM) incremented each time it is used. The CAM **400** authenticates

10   the message (**S1109**). Using the shared secret determined in the pairing operation
described above. Next, the CAM **400** sends the authenticated message back to source
200 (**S1102**, **S1110**) after which the source **200** also authenticates the message
(**S1103**) using the shared secret determined in the pairing operation described above.
Both source **200** and CAM **400** reset the access window according to the access

15   window logic **212** and **416** in the source **200** and the CAM **400** respectively. CAM **400**
then logs the user access (**S1112**), which may be used at a later time by the backend
700 (not shown in Figure 10) to determine how much a user should be charged. The
authentification logic **210** in source **200** (Fig. 10) verifies the authenticated messages
generated at step **S1103** by the source **200** and generated at step **S1109** by the CAM

20   **400**, respectively (**S1105**). Such authenticated messages should match since they are
each produced using the same shared session key. If the authenticated messages do
not match, then the source **200** stops the protocol. If the authenticated messages do
match (verify), then the source **200** sends the content of the desired program to be

accessed from the information receiving/generating device **204** in the source **200** to the

CAM **400** (**S1106, S1113**). The CA decrypt logic **408** in CAM **400** is used by the CAM

control logic **412** to decrypt the received information (**S1114**), and CAM **400** sends the

decrypted information to the sink **300** where it is displayed in useable form to the user

5   (**S1115, S1117**). Each of the source **200** and the CAM **400** determines if the access

window has expired using its respective access window logic **212** and **416** (**S1107,**

S1116). Each of the CAM **400** and the source **200** will independently stop processing

information when it independently determines that the access window in its respective

memory has expired.

10   Since the above protocol may cause the user to be charged for the entire time

window, the source **200** may preferably query the CAM **400** whether a previously

purchased window is still active. Such a query may precede the steps of Figure 11 with

the steps of Figure 12. As shown in Figure 12 the source **200** inquires of the CAM **400**

as to the amount of time remaining on the program along with the message containing

15   the counter value and the title (**S1201, S1207**). The CAM **400** uses a timer **410** (Fig.

10) to determine the amount of time remaining. The CAM **400** authenticates the

counter value and the actual time remaining (**S1208**) using the authentification logic **414**

(Fig. 10) and sends the actual time remaining back to the source **200** along with the

authenticated counter value and actual time remaining (**S1209, S1202**). The source

20   **200**, authenticates the counter value and the time remaining using authentification logic

206 (**S1203**) and then determines if its authentification matches the authentification

done by the CAM **400**, i.e. verifies the authentification (**S1204**). If they match, then the

source sets the Time Remaining to YES (**S1205**). If the authentifications do not match,

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then the source sets the Time Remaining to NO (**S1206**). Thus the user will not be charged twice when the play, of for example a DVD disk, has been interrupted.

The authentication of the title preferably confirms to the source **200** that the CAM **400** is logging access to the information the source **200** is generating. This authorizes the source **200** to produce bits.

If the source **200** has a continuous play mode, it preferably tracks elapsed time, and terminates play when the window is empty.

This protocol is appropriate when there is a single billing window within which the information must be played, and especially when that window is significantly larger than the actual play of the information.

This embodiment may use 2-party (combined source and sink device), 3-party (separate source and sink devices), and/or PC architectures. Additionally, this embodiment does not require a non-volatile memory **202** in the source **200**, but it preferred that the source **200** be aware of title information, and restrictions on continuous play.

If the amount of information stream (i.e., footage) is used as a metric, instead of elapsed time since the window began, metered title-based PCR is a more appropriate protocol.

Metered Title-Based PCR

Another PCR protocol is Metered Title-Based PCR, in which the customer is charged incrementally for access to the information. An example of this embodiment and examples of the protocols used with it are shown in Figures 13 through 15. Figure

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13 illustrates a preferred apparatus for performing the operations illustrated in Figures

14 and 15. Logging and charges may be based on elapsed time or footage (i.e., bytes)

of information accessed.

In this embodiment, as shown in Figure 13, the source **200a** preferably contains

5   a information receiving/generating device **204a**, a freshness generator **206a**, source

control logic **208a**, authentication logic **210a**, and access window logic **212a**, a timer

214a, and a information meter **216a**. The freshness generator **206a** produces an

arbitrary value. The freshness generator **206a** may be a counter which produces a

count value or a random number generator which produces a random number.

10   Additionally, CAM **400a** preferably contains decryption logic **408a**, a timer **410a**, CAM

control logic **412a**, authentication logic **414a**, access window logic **416a**, and a

information meter **418a**. The access window logic **212a** and **416a** in the source **200a**

and CAM **400a**; respectively set a limit on the length of time a user is allowed access to

a specified program. Additionally, the information meter **216a** and the information meter

15   **418a** preferably measure the amount of information by detecting the number of data

packets containing information during the accessing process. It should be understood

by those of skill in the art that the information is transmitted by use data packets, each

being able to contain a predetermined amount of data. The timer **410a** and information

meter **418a** keep track of the amount of information used and/or the amount of a

20   window remaining. Additionally, it should be understood by those of skill in the art that

the exemplary protocols is Figures 14 and 15 are performed by the source control logic

208a and the CAM control logic **412a** respectively.

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In the protocol embodiment depicted in Figure 14, the source **200a** provides the CAM **400a** with a message including a freshness value generated by the freshness generator **206a**, the title of the program to be accessed, and a request for a play window (**S1401, S1408**). A new play window may extend a previously purchased but

5   not fully used play window. The CAM **400a** authenticates the message using authentication logic **414a**, and returns the authenticated message to the source **200a** (**S1409, S1410, S1402**). The source **200a** also authenticates the message using authentication logic **210** (**S1403**), and verifies the CAM authentication by determining if it matches the source authentication (**S1404**) using the source control logic **208a**. The

10 verification of the authentication by the CAM **400a** indicates that the CAM **400a** has charged for or has logged access to the request for the newly requested window in step **S1412**. Upon verifying the message, the source **200a** extends the access window by a predetermined amount labeled "PlayWindow" (**S1405**). Next, the source **200a** sends information regarding the desired program to be accessed from the information

15 receiving/generating device **204a** to the CAM **400a** (**S1406, S1413**). The CAM **400a** decrypts the information using the decryption logic **408a** (**S1414**), and provides the decrypted information to the sink device where it is displayed in a useable for to the user (**S1415, S1417**). Each of the source **200a** and the CAM **400a** determine if the access window has expired using its respective access window logics **212a** and **416a**

20 and its respective information meters **216a** and **418a** (**S1407, S1416**). Preferably, the access window logic **212a** and the access window logic **416a** each set the length of the access window, which may be represented by a period of time or by a predetermined number of data packets. When represented by a period of time, the timer **410a**

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monitors the remaining access window. When represented by a predetermined number of data packets, the information meter **216a** and the information meter **418a** each detect the number of data packets carrying the information of the desired program as it is being accessed. Once the predetermined number of data packets has been detected,

5   both the source **200a** and the CAM **400a** stop processing. Thus the user is allowed access to the information until either the CAM **400a** or the source **200a** determines that the access window has expired.

Additionally, at the end of information play, the source **200a** or the CAM **400a** may have an unused portion of the window, i.e. unused credit, so that, as shown in

10   Figure 15, it may request credit. The source **200a** provides the CAM **400a** with a message containing a request for credit, and authentication of the message including the counter value incremented by 1, and the request for credit, (i.e., request for credit, Authenticate (counter + 1, request for credit) **(S1501, S1502)**.   The CAM **400a** authenticates the request for credit and counter + 1 **(S1503)** using authentication logic

15   **414a**.   Then the CAM **400a** verifies the authentication by determining if the authentication performed by authentication logic **414a** matches with the authentication performed by authentication logic **210a (S1504)**.   If the authentication's match, i.e. verify, then CAM **400a** logs the request for credit **(S1505)**. If the authentications do not match, the protocol stops.

20   Additionally, the CAM **400a** may check that the freshness value in this request is linked to the most recent counter value used to request a play window. If a random value is used in lieu of a counter value (which require a non-volatile memory **202**), the value here can then be the most recent random value incremented by one. The CAM

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400a will stop processing information at that point, and the source **200a** will stop

generating information. The credit granted is preferably the smaller of that which the

CAM **400a** would have granted based on its own information, and what the source **200a**

asks for. If the CAM **400a** uses only the information that it tracks to determine the credit

5   due to the user, then a legitimate source **200a** can be used to play unlimited information

with a pirated CAM **400a**. Likewise, if the CAM **400** uses only the information given to it

by the source **200** to determine the credit due to the user, then a pirated source **200** can

be used to play unlimited information with a legitimate CAM **400**. Notice that the ability

of the source **200** to authenticate the request for credit need not confirm that the source

10   **200** is requesting the credit, just that the same device that the CAM **400** authenticated is

making the request.

Alternatively, instead of billing incrementally, this protocol may use deductions

from a single charge covering a large window, to debit against previously paid window.

For example, the user may request forty-eight hours of actual information access. In

15   that case, the source **200a** may use the CAM **400a** as a meter of remaining "footage"

within the window, where the source **200a** reports its incremental footage use. The

prepaid window may preferably be broken up into "checkpoints" corresponding to

requests for other play windows, and the source **200a** preferably reports ahead up to

the next checkpoint. The source **200a** reports to the CAM **400a** each time a checkpoint

20   is reached, and also each time information access is set-up again. If the debit window

is simply a time interval during which information may be accessed, title-based PCR

(discussed above) is adequate and simpler, since no intermediate reporting is

necessary.

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In this embodiment, whether using a credit approach or a debit approach, both the CAM **400a** and the source **200a** track information access, and stop play when the window is used up.   If the CAM **400a** does not track the amount of information accessed, then a pirated source device might be used to play information virtually for

5   free with a legitimate CAM. Likewise, if the source **200a** does not track the amount of information used, then a pirated CAM can decrypt unlimited information from the source **200a** after the source **200a** is given an authorized window by a legitimate CAM.

Metered Title-Based PCR with NVM (Non-Volatile Memory) on Source Device

10   The embodiment illustrated in Figure 16 uses substantially the same protocol as described above but in addition credit may be requested after power loss. Depending on the duty cycle of the NVMs **220b, 420b** in the information meter **218b** and the information meter **418b** respectfully (which may comprise a battery backed RAM ("BBRAM") and the NMV **402** and on how often the information meters **218b** and **418b**

15   are updated, the user should be charged almost exactly what (s)he is supposed to be charged. The NVM **220b** in the information meter **216b** is in the source **200b** and the NVM in the information meter **418b** in the CAM **400b**, preferably have storage capacities which are larger than the actual amount of information in the program, executable, etc., to be accessed.

20

Super-encryption and Re-encryption

In the embodiment, embodiment of Figure 17 and the corresponding protocol depicted in Figure 18, effective re-use of the information stream sent to and from the

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CAM **400c** is prevented.   For example, an attacker may attempt to intercept the information stream between the source **200c** and the CAM **400c**, or between the CAM **400c** and the sink **300c**. Although the stream of data between the source **200c** and the CAM **400c** could be decrypted by a generic pirated CAM. This protocol resists these

5   attacks, and, in addition, allows for arbitrarily fine billing granularity.

In Figure 17, the source **200c** preferably contains a information receiving/generating device **204c**, super encryption logic **222c**, and source logic **208c**. The super encryption device **222c** additionally encrypts using e.g., DES (Data Encryption Standard) FIPS Pub. 46-2 (1988) the information data, which is already

10   encrypted, thus creating super-encrypted information data. Additionally, the CAM **400c** preferably contains super decryption logic **422c**, conditional access decryption logic **408c**, which may be the same as decryption logic **422c**, an interface encryption logic **426c**, and a CAM control logic **412c**. The sink **300c** includes interface decryption logic **304c** which decrypts the re-encrypted information data from the CAM **400c** using a

15   negotiated session key. The sink **300c** also includes sink control logic **306c**. The backend **700** interacts with the CAM **400c**. An exemplary output device **500** is connected to the interface decryption logic **304c** although those of skill in the art will appreciate that the output device **500** may be integral with sink **300c**.

In an exemplary protocol for this embodiment, illustrated in Figure 18, the source

20   **200c** provides the CAM **400c** with the title of the program which is to be accessed **(S1801, S1804)**. The CAM **400c** preferably uses the title to locate the key required for the information access process (e.g., decryption) **(S1805)**, and to make a log entry (or charge) **(S1806)**. The source **200c** super-encrypts the protected information **(S1802)**

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using the super encrypt logic **222c**, preferably under the current session key that it shares with CAM **400c**. This (series of) session key(s) is established using a protocol such as the key derivation function discussed above. The sink **300c** sends the CAM **400c** a sink counter value (**S1814, S1807**) which is used by both the sink **300c** and the

5   CAM **400c** to derive a freshly negotiated session key (**S1815, S1808**). Then the CAM **400c** receives the super-encrypted information data from the source **200c** (**S1803, S1809**). The CAM **400c** super-decrypts the super-encrypted information using the super encrypt logic **422c** (**S1810**). Next the CAM **400c** decrypts the information itself (**S1811**) using the conditional access decryption logic **424c**, and CAM **400c** re-encrypts

10   the information under the negotiated session key with the sink **300c** (**S1812**) using the interface encryption logic **420c**. The sink **300c** receives the re-encrypted information from CAM **400c** and decrypts the re-encrypted information using the negotiated session key and the interface decryption logic **304c** (**S1813, S1816, S1817**). The sink **300c** is now able to process information data to present it, in a useable form to the user, e.g., to

15   be displayed, etc., on the output device **500**.

In step **S1814**, the sink **300c** preferably provides the CAM **400c** with a counter value (sink counter) which is used by the sink **300c** and the CAM **400c** to derive a fresh session key shared by the sink **300c** and the CAM **400c**. The sink **300c** preferably uses a new counter value for each iteration of the protocol.

20   In accordance with this embodiment, information access may be logged (or charged) each time the information program, etc., is accessed, not just the first time. Additionally, in this embodiment, the source **200c** super-encrypts the protected information using a key that implicitly (at least) authenticates the CAM **400c** as a

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preventive measure against reuse of information by a pirated CAM. Furthermore, freshness may be introduced into session keys used for super-encryption by the source **200c**, thus changing the session keys used for the super-encryption, i.e. used for communicating with the CAM **400c**. Additionally, freshness may preferably be

5 incorporated into the session keys by the legitimate sink **300c**, so that replay of an intercepted information stream to the sink **300c** will not be effectively decrypted by the sink device. Furthermore, replay of an intercepted information stream to the legitimate CAM **400c** results in additional logging of access, thus piracy can be detected or the pirate will simply be billed for the additional access.

10 In this embodiment, the CAM **400c** can log (bill) at any granularity, and the set top box **100c** (source and/or sink) need not be aware of the logging (billing) policy. Additionally, this embodiment may be used with 2-party, 3-party, and/or PC architectures.

15 **Combined Super-encryption/re-encryption and Title-based PCR**

The embodiment of Figure 19 combines the attributes of the Title-Based PCR with Super-encryption/re-encryption. It should be appreciated that architecture (of Figure 19) which performs the protocol of the present embodiment generally comprises a combination of Figures 10 and 17. For purposes of Figure 19, the source **200d** and

20 the CAM **400d** include all of the elements shown in the source **200** and the CAM **400** of Figure 10.

As shown in Figure 20, the source **200d** provides the CAM **400d** with a message preferably including a counter value and the title of the information, e.g., program to be

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accessed (**S2001, S2006**). The source **200d** and the CAM **400d**, each independently authenticate the message using the authentication logic **414d** of the CAM **400d** respectively (**S2007**). The source **200d** receives the authenticated message from the CAM **400d (S2008, S2002)** and the authentication logic **210d** of the source **200d**

5   verifies the authenticated message (**S2003**). If the authenticated messages match (**S2004**), then the source **200d** sends super-encrypted information to the CAM **400d**, where it is super-decrypted (**S2005, S2012, S2013**). The CAM **400d** then decrypts the information using the super decryption logic **422d** (which in this embodiment, may be the same as the conditional access decryption logic **408d** (**S2014**). At step **S2017**, the

10   sink **300d** provides the CAM **400d** with a counter value (sink count) which is used by the sink **300d** and the CAM **400d** to derive a fresh session key shared by the sink **300d** and the CAM **400d** (**S2010, S2011, S2018**). The sink **300d** preferably uses a new counter value for different information. The CAM **400d** re-encrypts the information under the negotiated session key with the sink **300d** (**S2015**) using the interface

15   encryption logic **426d**. The sink **300d** receives the re-encrypted information from CAM **400d** and decrypts the re-encrypted information using the negotiated session key and the interface decryption logic **304d** (**S2020**). The sink **300d** is now able to process the information data in a useable form to the user via, e.g., the output device **500**.

This embodiment takes advantage of the fact that authentication is potentially

20   stronger than encryption for reasons of high-speed data encryption and decryption implementation considerations.

Authenticating the media source

In the above embodiments, the PCR protocols do not prevent replay of the information stream from the source to the CAM because they cannot differentiate information bits from replayed information bits. In certain business models, this may be

5   adequate because such replay can result in logging. However, if the model requires that the CAM see proof that the information stream is being generated at the current play time by the source device **200**, the protocol of Figure 22, using the architecture of Figure 21, may be used.

In embodiment illustrated in Figure 21, the source **200e** preferably contains an

10   information receiving/generating device, a freshness generator **206e**, source control logic **208e**, authentication logic **210e**, and media authentication logic **224e**. The CAM **400e**, preferably contains a freshness generator **432e**, a CAM control logic **412e**, an authentication logic **414e** and media authentication logic **435e**. The freshness generator **432e** may be a counter or a random number generator. The operation of the

15   embodiment shown in Figure 21 is illustrated in the flow diagram shown in Figure 22. It should be appreciated that the protocol shown Figure 22 is preferably performed by the source control logic **208e** and the CAM control logic **412e** respectively.

The source **200e** preferably provides the CAM **400e** with a message which includes a counter value from the freshness generator **206e** (source counter) (**S2201**,

20   **S2208**). The freshness generator is preferably a counter in this embodiment. The CAM **400** authenticates the message (**S2209**) using authentication logic **412**. The CAM **400** also produces another counter value (CAM_counter) from the freshness generator **428e** and sends the authenticated message and the value CAM_counter to the source **200e**

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(S2210, S2202). The source 200e authenticates the message (S2203) using the authentication logic 210e. The CAM 400d authenticates the authenticated message and waits for a response from the source 200d (S2211). In this embodiment, the freshness generator 206e is preferably a counter. Upon verifying the authenticated

5   message (S2204), the source 200e sends the CAM 400e another message including the authenticated value CAM_counter and the title of the information, e.g., the program, executable, etc., to be accessed (S2205, S2206), and increments the value of CAM-_counter (S2207). The CAM 400e verifies the message generated in step S2205 with the message authenticated by the CAM in step S2211 (S2112, S2213), and upon

10   successful verification, the CAM 400e increments the value of CAM_counter (S2214) and returns to step S2211. If the authentication in step S2113 fails, the CAM 400e refuses to process information further.

A second protocol is illustrated in Figure 23 in which the freshness generator 432e in the CAM 400e is preferably a random number generator. The CAM 400e

15   provides the source 200e with a random number (S2305, S2301) from the freshness generator 432e. Both the source 200e and the CAM 400e authenticate the random number and the title of the program, executable, etc., to be accessed, i.e. authenticate(random, title) (S2302, S2306). The source 200e sends the authentication from authentication logic 210e (S2303) to CAM 400e (S2307) and increments the value

20   of the random number (S2304). Upon verification, the CAM 400e increments the random number (S2308, S2309) and the protocol continues. If the CAM 400e is unable to verify the authentication of the random number, it refuses to further process

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information. After sending the authenticated random and title to the CAM **400e** in step **S2303**, the source **200e** increments the value of the random number.

Since the protocols illustrated in Figures 22 and 23 do not authenticate the information stream directly, but prove that the source **200e** is accessing information, it

5   cannot distinguish from the specified title (i.e., the source **200e** believes that it is accessing authentic information). Therefore, it is necessary to repeat this protocol during information play. The frequency of repetition depends upon the threat. For example, if the goal is to require play from the original media, the protocol must be repeated often enough so that it is not worth the trouble to move the media between

10   source devices between challenges. The CAM **400e** must not continue to process information decryption if it does not receive the expected authenticated message.

The efficacy of this protocol depends upon it being difficult to produce a pirated media and pirated source devices. Pirating source devices may be difficult if legitimate source devices contain proprietary technology that a pirate cannot efficiently produce on

15   a large scale. Alternatively, each legitimate source device may have verifiable secrets that each can use to authenticate itself to a CAM. Individualization of these secrets may be combined with the use of pairing as an anti-piracy enforcement mechanism.

Combined   Super-encryption/Re-encryption,   Title-based   PCR,   and   Media Authentication

The embodiment of Figure 24 combines super-encryption/re-encryption with title-

5   based PCR and media authentication . It should be appreciated that the architecture

which performs the protocol of the present embodiment (e.g. Figure 25) generally

comprises combination of the architectures illustrated in Figures 10, 17, and 21. For

purposes of Figure 24 the source **200f** and the CAM **400f** include all essential

elements shown in the source **200** and the CAM **400** of Figure 10 and all essential

10   elements of the source **200c** and the CAM **400c** of Figure 17.

As shown in the flow diagram of Figure 25, the source **200f** provides the CAM

400f with a message containing a source counter value and the title of the program to

be accessed (steps **S2501, S2508**). The CAM **400f** authenticates the message (**S2509**)

using authentication logic **414f** and provides the authenticated message to the source

15   **200f (S2510)**. The CAM **400f** also produces another counter value (CAM_counter) from

freshness generator (a.k.a. cam counter) **432** and sends the authenticated message

and value CAM_counter to the source **200f (S2510, S2502)**, where, in this embodiment,

the freshness generator **206f** is preferably a counter. The CAM **400f** uses the title to key

the information access and process, e.g., to decrypt and to make a log entry (**S2511**).

20   The source **200f** verifies the authenticity of the message using authentication logic **210f**

(**S2504**). If verification fails, the source **200f** stops generating information and the

protocol ends. The sink **300f** sends the CAM **400f** a sink counter value (**S2523, S2512**)

which is used by both the sink **300f** and the CAM **400f** to derive a negotiated session

key (**S2513, S2524**). Upon verifying the authenticated message (**S2504**), the source

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200f sends the CAM **400f** another message including the authenticated value of CAM-_counter and session key evidence (**S2505, S2515**). The CAM **400f** verifies the authenticity of the message by determining if it matches the authentication previously preformed by the CAM **400f** in step **S2514**. If verification fails, the CAM **400f** stops

5   processing information and the protocol ends. If the authenticated messages verify, the CAM **400f** increments the freshness generator **432f**, e.g., a cam-counter (**S2517**). Then the CAM **400f** receives the super-encrypted information data from the source **200f** (**S2507, S2318**). The CAM **400f** super-decrypts the super-encrypted information using the super-decryption logic **422f** (**S2519**). The CAM **400f** decrypts the information *per se*

10   (**S2520**) using the CA decryption logic **408f**, and then re-encrypts the information under the negotiated session key with the sink **300f** (**S2521**) using the interface decryption logic **426f**. The sink **300f** receives the re-encrypted information from CAM **400f** (**S2523, S2525**) and decrypts the re-encrypted information using the negotiated session key and the interface decryption logic **306f** (**S2526**). The sink **300f** is now able to process the

15   information data in a form useable to the user.

Although the protocol of this embodiment has been described as using a freshness generator **432** in the form of a counter in the CAM **400f** for authentication, it can also use a random number generator in the CAM **400f** in place of the cam counter in a manner similar to that discussed above in connection with Figures 21 and 23.

20   If the title field is skipped in this embodiment, the protocol will preferably combine only super-encryption/re-encryption and media authentication. Additionally, the session key evidence provided by the source **200f** to the CAM **400f** in this embodiment is preferably sufficient for the CAM **400f** to freshly confirm that the source

200f knows the correct session key. For example, the session key evidence may be a component of the session key itself, a function of the key, or other evidence bound to that key. The authentication message preferably does not compromise the session key.

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Data based PCR with NVM (non-volatile memory) on STB and BBRAM (Battery Backed RAM) on CAM.

The operation of Figure 26 will now be described with references to the flow diagram in Figure 27. This embodiment uses a non volitile memory ("NVM") **116** on the

10   set top box **100** (STB) and a battery backed RAM ("BBRAM") **406g** on the CAM **400g**. Additionally, while the set top box STB **100** is described as comprising a combined source and sink device, it should be appreciated that the STB **100** may only include the source or the sink, the other being external to the STB **100**.

In this embodiment, Figure 26, the STB **100** (which may be a combination of the

15   source **200** and the sink **300**) preferably contains a information receiving/generating device **102**, an index counter **104** in an NVM **116**, cryptographic logic device **106**, an STB logic device **108**, a key logic **110**, and seed generation logic **112** in the NVM **116**. Additionally, the CAM **400g** preferably contains cryptographic logic **440g**, an index counter **442** in an NVM **406g**, a key logic **446**, and a seed generation logic **448** in the

20   NVM **406g**. It should be appreciated that the protocol shown Figure 27 will preferably be performed by the STB control logic **108** and the CAM control logic **444** respectively.

As shown in the flow diagram of Figure 27, the STB **100**, provides the CAM **400** with a negotiation message which establishes a new shared secret value (seed) that will

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be used to authenticate the CAM **400g** to the set top box **100 (S2701, S2707)**. This message occurs only when the CAM **400g** and the STB **100** are not in cryptographic sync. The information provided by the information provider is preferably provided in discrete packets of information, and the STB **100** and the CAM **400** both count the

5   number of packets of information they are provided, using an index counter **104** preferably contained within the NVM **116** and an index counter **442** preferably contained within a NVM **406g**, in the STB **100** and CAM **400g** respectively. After the message is received by the CAM **400g**, the STB **100** and the CAM **400** must be synchronized on their respective counts; that is, they begin counting from the same packet.

10   At step **S2708** the CAM **400g** provides the STB **100** with a message including a Challenge which is authenticated and encrypted, and a status which is authenticated **(S2708, S2702)**. The status indicates to the STB **100** whether it (the STB **100**) is still cryptographically synchronized with the CAM **400g (S2703)**, i.e. in cryptographic sync.

In other words, the status indicates whether the CAM **400g** and the STB **100** are

15   still using the same session key. That is, the status indicates whether the authentication and encryption are done using the previously defined Authenticate and Encrypt subroutines respectively. The challenge authentication and challenge encryption are preferably separate operations. From the challenge, the STB **100** can infer the index of the packet for which it must generate a response (i.e., the challenged packet). The STB

20   **100** also infers, from the challenge, the packet index after which the generated response must be sent (i.e., the beginning of the response window, which follows the challenge window). If the STB **100** determines it is not in cryptographic sync, the protocol returns to step **S2701**. If the STB **100** and CAM **400g** are in cryptographic

sync, then, in step **S2504**, the STB **100** determines if it is in packet sync with CAM **400g**. If the STB **100** determines that it is not in sync (**S2704**), the STB **100** sends the CAM **400g** an authenticated request for packet resync (**S2706, S2709**). If the STB **100** and CAM **400g** are in packet sync (**S2704**) the operation advances to step **S2705** where the STB **100** provides CAM **400g** with an authenticated response (**S2705, S2710**). The authenticated response is calculated from the challenged packet, and it may depend upon the information packet that the STB **100** sent, and upon the plain text that corresponds to that packet. The CAM **400g** then verifies the authenticated response (**S2711**). If the response is received during the response window and is verified, then CAM **400g** decrements the NACK counter. Control then returns to step **S2708**.

Preferably, the authenticated response in step **S2705** is not sent immediately after it is calculated. Rather it may not be sent until the beginning of the response window, but preferably must be sent before the end of that window. Alternatively, an Encrypted response may be sent by the STB **100** in step **S2705** instead of the Authenticated response, in which case the CAM **400g**, applies the Confirm subroutine. In this case, the Hash(Response), rather than the response, may be encrypted.

The windows described above correspond to several distinguished indices. The challenge window begins when the challenge is sent, and ends just before the response window begins. Preferably, the challenged packet index is within the challenge window, and is preferably randomized within the window. The challenge window is preferably of a random length which is defined by the CAM **400g** each time the protocol shown in Figure 27 is performed. The response window is preferably of a fixed short length,

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although it should be large enough to allow the response from the STB **100** to be delivered reliably to the CAM **400g**.

The CAM **400** delivers its new challenge after the response window ends. This challenge acknowledges the response provided by the STB **100**, if the response verifies

5 (e.g., if the CAM **400** calculates the same response).

If the STB **100** does not satisfactorily receive an anticipated challenge, the STB **100** will suspend information packet transmittal, preferably by no longer sending packets to the CAM **400g** and by no longer interpreting packets returned from the CAM **400g**.

10 In addition to the challenged packet index and the beginning of the response window, the STB **100** infers a value RDM from the challenge. The value RDM is used to authenticate and encrypt subsequent messages; that is, the value RDM becomes the session key used instead of the negotiated session key. Preferably, the first session key authenticates the CAM **400g** to the STB **100**, and subsequent session keys confirm

15 to the STB **100** that it is still communicating with the CAM **400g**, and confirm to the CAM **400g** that it is still communicating with the same STB **100** with which it originally negotiated a key.

Although the STB **100** responds to challenges from the CAM **400g**, it is actually the legitimate operation of the paired CAM **400g** that is being verified by the STB **100**.

20 The STB **100** will refuse to communicate information packets if it does not receive a challenge, e.g., from the paired CAM **400g**. Preferably, if the legitimate CAM **400g** detects too many violations (such as due to the presence of a pirated CAM), it will refuse to generate a challenge, and the STB **100** will reject the pirated CAM. The CAM

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400g accumulates NACKs (negative acknowledgments) as a means of tracking potential violations.

The protocol establishes a shared secret value the first time the STB **100** powers up with a new CAM **400g**. If the challenge and status are OK, the STB **100** sets a

5　NACK-Request flag, in a microprocessor **114** on the STB **100**, and writes it and RDM into the NVM **116**. When the response is computed by the microprocessor **114** on the STB **100**, this response (with the current associated value of RDM) is held in the NVM **116** until communications with the CAM **400g** and processing, with respect to this response, have been concluded. It should be appreciated that in Figure 26, the

10　microprocessor **114** and NVM **116** are depicted schematically, as opposed to architecturally.

On the CAM **400g**, a NACK is charged or accumulated at the beginning of each response window, and the NACK counter is decremented (e.g., a NACK is unchanged) if the correct response is received by the end of the response window. Whenever the

15　CAM **400g** issues a new challenge, ant current challenge ends. In particular, if the CAM **400g** is currently in a response window, that response window ends. The CAM **400g** preferably contains a microprocessor **450**, schematically illustrated in Figure 26, that computes a response and determines the NACK status, the computed response and the NACK status of the challenge are written to the NVM **406g** on the CAM **400g**.

20　The shared secret value (seed) which is negotiated may, for example, result from the use of a KDF variable such as a counter together with a long-term shared secret value.

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If the response is early (i.e. delivered before the response window begins) but authentic in that the encrypted response message header, if any, sent with the authenticated response is correct, the CAM **400g** charges a NACK and issues a new challenge (including a new value of RDM), thus prematurely ending the current

5   challenge.

If an authenticated request for packet resync verifies correctly, the CAM **400g** sets itself the current packet index of the STB **100**, and issues a new challenge, thus prematurely ending the current challenge.

The CAM **400g** sets a CAM flag during processing of a shared secret value

10   negotiation message which has the NACK-Request flag set. The CAM **400g** resets the CAM flag in response to a subsequent negotiation message which does not have the NACK-Request flag set, or upon receipt of information packets, or upon exceeding the negotiation message retry or time-out limit if this tracking capability is implemented on the CAM. A NACK is accumulated on

15   the CAM **400g** in response to a negotiation message which has the NACK-Request flag set, unless the tracking capability is implemented and the CAM flag is already set upon receipt of the message. The STB **100** does not accept the returned challenge message if the CAM flag value in status does not match the NACK-Request flag setting of the STB **100**, in which case the STB **100** sends

20   another negotiation message to the CAM **400g**.

In this protocol the STB does not have to be aware of the billing information, or the billing policy.

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Alternatively, in this embodiment, the CAM **400g**, rather than using a BBRAM for storage, may log ahead one mini-interval.   Preferably, each logging record of information access also includes the type/level and/or the title-key ID corresponding to the CA key used by the CAM **400g** to decrypt information.

5   Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. For example, it will be apparent to those of skill in the art that the PCR system(s) of the present invention can be used in conjunction with other information anti-piracy techniques such as requiring an original

10   media as proposed by Linnartz in a paper titled "Philips Electronics Response to Call for Proposals" issued by the Data Hiding SubGroup Copy Protection Technical Working Group. Also, it will be appreciated that the various protocols and architectures described herein can be tailored to meet the security requirements of a particular application by selectively adopting portions of a given protocol and/or architecture.

15   Therefore, unless such changes and/or modifications depart from the scope of the present invention as defined by the appended claims, they should be construed as being included therein.

CLAIMS

We claim:

1   1.   An apparatus for preventing unauthorized access to information,

2   comprising:

3   a non-renewable device for receiving the information to be processed; and

4   a renewable device for authorizing the non-renewable device to process the

5   information, said non-renewable device being paired with said renewable device by a

6   shared secret which enables each of the non-renewable device and the renewable

7   device to communicate with the other, wherein the renewable device communicates

8   with the non-renewable device according to a predetermined protocol using the shared

9   secret.

1   2.   The apparatus according to claim 1 wherein the information is encrypted

2   and the non-renewable device includes an output for outputting the information to the

3   renewable device, and wherein the renewable device includes a decryption logic for

4   decrypting the information, and an output for outputting the decrypted information to the

5   non-renewable device.

1   3.   The apparatus according to any one of claims 1 and 2 wherein the

2   information comprises a specified program, and wherein at least one of said non-

3   renewable device and said renewable device include an access window logic for

4   generating an access time window of a predetermined time duration for the specified

5   program, said time window limiting access to said specified program to said

6   predetermined time duration.

1   4.   The apparatus according to claim 3 wherein said non-renewable device

2   includes a control logic generating a query message, and an authentication logic for

3   authenticating information contained in said query message and information contained

4   in a response message using said shared secret thereby generating a non-renewable

5   device authentication message,

6   wherein the renewable device includes an authentication logic for authenticating

7   the information contained in the query message and the information in the response

8   message using said shared secret, thereby generating a renewable device

9   authentication message, the renewable device further including a control logic operable

10   to generate the response message and to provide said non-renewable device with said

11   response message and the renewable device authentication message, said non-

12   renewable device control logic being further operable to match the renewable device

13   authentication message with the non-renewable device authentication message, and to

14   provide the renewable device with said specified program if the renewable device

15   authentication message matches the non-renewable device authentication message.

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1   5.   The apparatus according to claim 4 wherein the renewable device logs

2   access to said information after providing the response message to the non-renewable

3   device.

1   6.   The apparatus according to claim 4 wherein said query message includes

2   at least one of an arbitrary value and a title of said specified program..

1   7.   The apparatus according to claim 6 further comprising a freshness

2   generator associated with the non-renewable device for generating said arbitrary value.

1   8.   The apparatus according to claim 7 wherein said freshness generator

2   comprises a counter.

1   9.   The apparatus according to claim 7 wherein said freshness generator

2   comprises a random number generator.

1   10.   The apparatus according to claim 4 wherein said query message further

2   includes a request for remaining access time, said response message including an

3   indication of the time remaining, and wherein said non-renewable device includes an

4   access window logic which indicates time remaining if the renewable device

5   authentication message matches the non-renewable device authentication message.

1   11.   The apparatus according to claim 4 wherein said message further includes

2   a request for a process window and said renewable device further includes an

3   information meter to measure the amount of information which has been accessed, and

4   wherein the renewable device provides a process window time within the response

5   message, whereby the access time window may be extended to include the process

6   window time.

1   12.   The apparatus according to claim 11 wherein said non-renewable device

2   further includes an information meter to measure the amount of information which has

3   been accessed; wherein if said response message matches said authenticated

4   response message, the non-renewable device extends the access time window to

5   include the process window time.

1   13.   The apparatus according to claim 12 wherein the information meter in said

2   renewable device and the information meter in said non-renewable device each include

3   a non-volatile memory.

1   14.   The apparatus according to claim 12 wherein each of said non-renewable

2   device and said renewable device includes an access window logic device for

3   generating an access time window, wherein access to said information is limited to the

4   shorter of the access time windows generated by said access window logic devices.

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1   15.   The apparatus according to claim 12 wherein each of said non-renewable

2   device and said renewable device includes an access window logic device for

3   determining the amount of access time remaining, and for generating a credit amount ,

4   wherein said credit amount is determined by the shorter of the access time windows

5   generated by said access window logic devices.

1   16.   The apparatus according to claim 4, wherein the information is encrypted,

2   and said non-renewable device further includes a super-encryption logic for super-

3   encrypting the information; and

4   wherein said renewable device further includes a super-decryption logic for

5   super-decrypting the super-encrypted information, and a decryption logic for decrypting

6   the information.

1   17.   The apparatus according to claim 16 wherein said renewable device

2   further includes an interface encryption logic for re-encrypting the decrypted information,

3   and wherein said non-renewable device further includes an interface decryption logic

4   for decrypting the re-encrypted information.

1   18.   The apparatus according to claim 17 wherein said information includes a

2   specified program to be accessed, and wherein said non-renewable device includes a

3   control logic operable to generate a message, said renewable device including a control

4   logic operable to determine a super-decryption key from said message, and to negotiate

5   keys for super-decryption and re-encryption.

1   19.   The apparatus according to claim 18 wherein said non-renewable device

2   comprises a source operable to generate said message, said source including said

3   super-encryption logic and said control logic; and a sink operable to negotiate a re-

4   encryption key, said sink including said interface decryption logic and said control logic.

1   20.   The apparatus according to claim 19 wherein said source and said sink

2   comprise an integrated device.

1   21.   The apparatus according to claim 19 wherein said source and sink

2   comprise separate devices.

1   22.   The apparatus according to claim 19 wherein said message includes a

2   title of said specified program.

1   23.   The apparatus according to claim 19 wherein the control logic of said

2   renewable device determines a super-decryption key based, at least in part, on the

3   content of said message.

1   24.   The apparatus according to claim 17 wherein said non-renewable device

2   includes a non-renewable device media authentication logic for authenticating a media

3   on which the information to be accessed is carried, and said renewable device includes

4   a media authentication logic for authenticating the media.

1   25.   The apparatus according to claim 24 wherein the renewable device

2   provides an arbitrary value to the non-renewable device.

1   26.   The apparatus according to claim 25 further comprising a freshness

2   generator associated with said renewable device for generating said arbitrary value.

1.   27.   The apparatus according to claim 26 wherein said freshness generator

2   comprises a counter.

1   28.   The apparatus according to claim 26 wherein said freshness generator

2   comprises a random number generator.

1   29.   The apparatus according to claim 1 wherein the information is encrypted,

2   and said non-renewable device further includes a super-encryption logic for super-

3   encrypting the information; and

4   wherein said renewable device further includes a super-decryption logic for

5   super-decrypting the super-encrypted information, and a decryption logic for decrypting

6   the information.

1   30.   The apparatus according to claim 29 wherein said renewable device

2   further includes an interface encryption logic for re-encrypting the decrypted information,

3   and wherein said non-renewable device further includes an interface decryption logic

4   for decrypting the re-encrypted information.

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1   31.   The apparatus according to claim 30 wherein said information includes a

2   specified program to be accessed, said non-renewable device includes a control logic

3   operable to generate a message, and said renewable device includes a control logic

4   operable to determine a super-decryption key from said message and to generate keys

5   for super-decryption and re-encryption.

1   32.   The apparatus according to claim 31 wherein said non-renewable device

2   comprises a source, said source including said super-encryption logic and said control

3   logic; and operable to negotiate a re-encryption key, said sink including said interface

4   decryption logic and said control logic.

1   33.   The apparatus according to claim 32 wherein said source and said sink

2   copmrise an integrated device.

1   34.   The apparatus according to claim 32 wherein said source and sink

2   comprise separate devices.

1   35.   The apparatus according to claim 32 wherein said message includes a

2   title of said specified program.

1   36.   The apparatus according to claim 32 wherein the control logic of said

2   renewable device determines a super-decryption key based, at least in part, on the

3   content of said message.

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1   37.   The apparatus according to claim 30 wherein said non-renewable device

2   includes a non-renewable device media authentication logic for authenticating a media

3   on which the information to be accessed is carried, and said renewable device includes

4   a media authentication logic for authenticating the media.

1   38.   The apparatus according to claim 37 wherein said renewable device

2   provides an arbitrary value to said non-renewable device.

1   39.   The apparatus according to claim 38 further comprising a freshness

2   generator associated with said renewable device for generating said arbitrary value.

1   40.   The apparatus according to claim 39 wherein said freshness generator

2   comprises a counter.

1   41.   The apparatus according to claim 39 wherein said freshness generator

2   comprises a random number generator.

1   42.   The apparatus according to claim 1 wherein said non-renewable device

2   includes a non-renewable device media authentication logic for authenticating a media

3   on which the information to be accessed is carried, and said renewable device includes

4   a media authentication logic for authenticating the media.

1   43.   The apparatus according to claim 42 wherein said renewable device

2   provides an arbitrary value to said non-renewable device.

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1   44.   The apparatus according to claim 43 further comprising a freshness

2   generator associated with said renewable device for generating said arbitrary value.

1   45.   The apparatus according to claim 44 wherein said freshness generator

2   comprises a counter.

1   46.   The apparatus according to claim 45 wherein said freshness generator

2   comprises a random number generator.

1   47.   A method of preventing unauthorized access to information in a system

2   comprising a non-renewable device having a control logic and a renewable device

3   having a control logic, the method comprising the steps of:

4   pairing a non-renewable device with a renewable device;

5   selectively authenticating messages exchanged between the non-renewable and

6   renewable devices and sending an authenticated message based on said selected

7   messages from said one of the non-renewable and renewable device to the other of

8   said non-renewable and renewable devices;

9   verifying the authenticated message in the other of said non-renewable and

10   renewable devices; and

11   authorizing access to said information.

1   48. The method according to claim 47 wherein said step of pairing further

2   comprises the steps of:

3   generating an ID value for the non-renewable device;

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4   generating an ID value for the renewable device;

5   generating at least one certificate based on the ID value for said non-renewable

6   device and the ID value for said renewable device; and

7   sending said at least one certificate to at least one of the non-renewable and renewable

8   devices.

1   49.   The method according to claim 48 wherein said ID value for said

2   renewable device comprises a public key.

1   50.   The method according to claim 48 wherein the step of generating the ID

2   value for the non-renewable device further comprises sending the ID value to the

3   renewable device.

1   51.   The method according to claim 48 wherein said system includes a

2   backend system and wherein the step of generating a certificate further comprises

3   generating said certificate at the backend system.

1   52.   The method according to claim 51 wherein said at least one certificate

2   binds the ID value of the non-renewable device to the renewable device.

1   53.   The method according to claim 51 wherein said at least one certificate

2   binds the ID value of the renewable device to the non-renewable device.

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1   54.   The method according to claim 51 wherein said at least one certificate

2   binds a non-renewable device public key to the non-renewable device ID value.

1   55.   The method according to claim 54 further comprising the step of providing

2   the at least one certificate to the non-renewable device if the non-renewable device

3   does not contain the at least one certificate.

1   56.   The method according to claim 54 wherein said at least one certificate

2   binds a renewable device public key to the renewable device ID value.

1   57.   The method according to claim 48 wherein the non-renewable device

2   comprises a source device.

1   58.   The method according to claim 48 wherein the non-renewable device comprises

2   a sink device.

1   59.   The method according to claim 47 wherein said system includes a

2   backend system and said step of pairing further comprises the steps of:

3   generating an ID value for the non-renewable device;

4   determining if the non-renewable device contains an Entity_Certificate;

5   sending said Entity_Certificate to said renewable device and the backend

6   system;

7   .   determining if said backend system contains another Entity_Certificate;

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8   sending said renewable device one of said Entity _Certificate and said another

9   Entity Certificate; and

10   sending said renewable device a Cross_Certificate.

1   60.   The method according to claim 47 wherein said system includes a

2   backend system and said step of pairing further comprises the steps of:

3   generating an ID value for the non-renewable device;

4   determining secret information of the non-renewable device in the backend

5   system based on the ID value for the non-renewable device; and

6   sending the secret information to said renewable device.

1   61.   The method according to claim 54 further comprising the step of providing

2   to said non-renewable device the secret information if said non-renewable device does

3   not contain the secret information.

1   62.   The method according to claim 60 wherein the non-renewable device

2   comprises a source device.

1   63.   The method according to claim 61 wherein the non-renewable device

2   comprises a sink device.

1   64.   The method according to claim 47 wherein each of the non-renewable and

2   renewable devices includes an authentication logic, and wherein said step of selectively

3   authenticating messages further comprises the steps of:

4   sending a query message from said non-renewable device to said renewable

5   device;

6   authenticating the information contained in said query message and information

7   in a response message using a shared secret, thereby generating a renewable device

8   authentication message, said response message being generated by the renewable

9   device;

10   authenticating information contained in the query message and information

11   contained in the response message using said shared secret, thereby generating a non-

12   renewable device authentication message; and

13   verifying that said renewable device authentication message matches said non-

14   renewable device authentication message.

1   65.   The method according to claim 64 wherein said query message includes

2   an arbitrary value and a title of a specified program of said information, and said

3   response message contains no information.

1   66.   The method according to claim 64 further comprising the step of logging

2   access to said information after providing the response message to the non-renewable

3   device by the renewable device.

1   67.   The method according to claim 64 wherein the non-renewable device

2   further comprises a freshness generator and further comprising the step of generating

3   said arbitrary value.

1   68.   The method according to claim 67 wherein the freshness generator

2   comprises a counter and said arbitrary value is a count value.

1   69.   The method according to claim 67 wherein the freshness generator

2   comprises a random number generator and said arbitrary value is a random number.

1   70.   The method according to claim 64 wherein said query message further

2   includes a request for remaining access time, and said response message includes an

3   indication of the time remaining, and wherein said non-renewable device includes an

4   access window logic, further comprising the step of

5   indicating time remaining if said renewable device authentication message matches

6   said non-renewable device authentication message.

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1   71.   The method according to claim 64 wherein said message further includes

2   a request for a process window and said renewable device further includes an

3   information meter and further comprising the steps of:

4   measuring the amount of information which has been accessed by said

5   renewable device; and

6   providing a process window time within the response message, wherein the access time

7   window may be extended to include the process window time.

1   72.   The method according to claim 71 wherein said non-renewable device

2   further includes an information meter, and further comprising the steps of:

3   measuring the amount of information which has been accessed by the non-

4   renewable device; and

5   extending the access time window to include said process window time if said

6   renewable device authentication message matches said non-renewable device

7   authentication message.

1   73.   The method according to claim 72 wherein each of said non-renewable

2   device and said renewable device includes an access window logic device for

3   determining the amount of access time remaining, and further comprising the steps of:

4   generating an access time window at the non-renewable device;

5   generating an access time window at the renewable device; and

6   limiting access to the shorter one of the access time windows generated at the non-

7   renewable and renewable devices.

1   74.   The method according to claim 73 further comprises the step of:

2   generating an amount of credit to be given to a user based on the access based

3   on said step of limiting access.

1   75.   The method according to claim 64 wherein said information is encrypted,

2   the message includes a title of a specified program of said information, the non-

3   renewable device includes a super-encryption logic, and the renewable device includes

4   a super-decryption logic, and further comprising the steps of:

5   super-encrypting said information in said non-renewable device;

6   providing said super-encrypted information to said renewable device; and

7   decrypting said super-encrypted information in said renewable device.

1   76.   The method according to claim 75 wherein the renewable device includes

2   decryption logic, and further comprising the step of:

3   decrypting said information at said renewable device.

1   77.   The method according to claim 76 wherein said non-renewable device

2   comprises a source device, said renewable device comprises re-encryption logic, and

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3   said system further comprises a sink device which comprises decryption logic, and

4   further comprising the steps of:

5   re-encrypting said decrypted information;

6   providing re-encrypted information to the sink device; and

7   decrypting said re-encrypted information.

1   78.   The method according to claim 77 further comprising the step of:

2   determining an interface encryption key to be used in said step of re-encrypting

3   and said step of decrypting.

1   79.   The method according to claim 78 wherein said step of determining an

2   interface encryption key further comprises the steps of:

3   sending a sink arbitrary value from said sink device to said renewable device;

4   independently deriving the interface encryption key using information contained

5   in said sink arbitrary value at said renewable device; and

6   independently deriving the interface encryption key using information contained

7   in said sink arbitrary value at said sink device.

1   80.   The method according to claim 75 further comprising the steps of:

2   determining a super-encryption key used in said step of super-encrypting and

3   said step of super-decrypting.

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1   81.   The method according to claim 80 wherein the step of determining a

2   super-encryption key further comprises the steps of:

3   using information based on said title of a specified program to determine said super-

4   encryption key at said renewable device.

1   82.   The method according to claim 75 wherein said message further includes

2   an arbitrary value, and further comprising the steps of:

3   sending a media query message from the renewable device to the non-

4   renewable device;

5   authenticating information contained in said media query message and

6   information contained in a media response message generated at said non-renewable

7   device thereby generating a non-renewable device media authenticated message;

8   sending said media response message and said non-renewable device media

9   authenticated message to said renewable device;

10   authenticating the information contained in said media response message and

11   the information contained in said media query message at said renewable device

·12   thereby generating renewable device media authenticated message; and

13   verifying said non-renewable device media authenticated message with said renewable

14   device media authenticated message at said renewable device.

1   83.   The method according to claim 82 wherein the media query message is

2   contained in said response message.

1   84.   The method according to claim 82 wherein the renewable device includes

2   a counter for generating a renewable device count value which is included in said media

3   query message, and further comprising the steps of:

4   incrementing said renewable device count value at the non-renewable device;

5   and

6   incrementing said renewable device count value at the renewable device if the

7   verification step is successful.

1   85.   The method according to claim 82 wherein the renewable device includes

2   a random number generator for generating a renewable device random value which is

3   included in said media query message, and further comprising the steps of:

4   incrementing said renewable device random value at said non-renewable device;

5   and

6   incrementing said renewable device random value at said renewable device if said

7   verification step is successful.

1   86.   A method of preventing unauthorized access to information, which is

2   encrypted, in a system comprising a non-renewable device having a control logic and a

3   super-encryption logic, a renewable device having a control logic and a super-

4   decryption logic, the method comprising the steps of:

5   super-encrypting said information in said non-renewable device;

6   providing said super-encrypted information to said renewable device; and

7   decrypting said super-encrypted information in said renewable device.

1   87.   The method according to claim 86 wherein the renewable device includes

2   decryption logic, and further comprising the step of:

3   decrypting the information at said renewable device.

1   88.   The method according to claim 87 wherein said non-renewable device comprises

2   a source device, said renewable device comprises re-encryption logic, and said system

3   further comprises a sink device which comprises decryption logic, and further

4   comprising the steps of:

5   re-encrypting said decrypted information;

6   providing re-encrypted information to the sink device; and

7   decrypting said re-encrypted information.

1   89.   The method according to claim 88 further comprising the step of:

2   determining an interface encryption key to be used in said steps of re-encrypting

3   and decrypting.

1   90.   The method according to claim 89 wherein said step of determining an

2   interface encryption key further comprises the steps of:

3   sending a sink arbitrary value from said sink device to said renewable device;

4   independently deriving the interface encryption key using information contained

5   in said sink arbitrary value at said renewable device; and

6   independently deriving the interface encryption key using information contained

7   in said sink arbitrary value at said sink device.

1   91.   The method according to claim 86 further comprising the steps of:

2   determining a super-encryption key used in said step of super-encrypting and

3   said step of super-decrypting.

1   92.   The method according to claim 91 wherein the information comprises a

2   specified program having a title and the step of determining a super-encryption key

3   further comprises the step of:

4   using information based on the title of the specified program to determine the super-

5   encryption key at the renewable device.

1   93.   A method of preventing unauthorized access to information in a system

2   comprising a non-renewable device having a control logic and a renewable device

3   having a control logic, the method comprising the steps of:

4   sending media query message from the renewable device to the non-renewable

5   device;

6   authenticating information contained in the media query message and

7   information contained in a media response message generated at the non-renewable

8   device, thereby generating a non-renewable device media authenticated message;

9   sending said media response message and said non-renewable device media

10 authenticated message to said renewable device;

11   authenticating the information contained in the media response message and the

12 information contained in the media query message at said renewable device, thereby

13 generating a renewable device media authenticated message; and

14 verifying said non-renewable device media authenticated message with said renewable

15 device media authenticated message at said renewable device.

1   94.   The method according to claim 93, wherein the renewable device includes

2   a counter for generating a renewable device count value which is included in said media

3   query message, and further comprising the steps of:

4   incrementing said renewable device count value at said non-renewable device;

5   and

6   incrementing said renewable device count value at said renewable device if said

7   verification step is successful.

1   95.   The method according to claim 93 wherein the renewable device includes

2   a random number generator for generating a renewable device random value which is

3   included in said media query message, and further comprising the steps of:

4   incrementing said renewable device random value at said non-renewable device;

5   and

6   incrementing said renewable device random value at said renewable device if said

7   verification step is successful.

1   96.   A method of preventing unauthorized access to information in a system

2   comprising a non-renewable device and a renewable device, the method comprising the

3   steps of:

4   (a) sending a seed negotiation request from said non-renewable device to said

5   renewable device;

6   (b) sending a challenge and a status query from said renewable device to said

7   non-renewable device;

8   (c) determining if said non-renewable device and said renewable device are in

9   cryptographic sync; and

10   (d) returning to step (a) if said non-renewable device and renewable device are not in

11   cryptographic sync.

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6   incrementing said renewable device count value at said renewable device if said

7   verification step is successful.

1   95.   The method according to claim 93 wherein the renewable device includes

2   a random number generator for generating a renewable device random value which is

3   included in said media query message, and further comprising the steps of:

4   incrementing said renewable device random value at said non-renewable device;

5   and

6   incrementing said renewable device random value at said renewable device if said

7   verification step is successful.

1   96.   A method of preventing unauthorized access to information in a system

2   comprising a non-renewable device and a renewable device, the method comprising the

3   steps of:

4   (a) sending a seed negotiation request from said non-renewable device to said

5   renewable device;

6   (b) sending a challenge and a status query from said renewable device to said

7   non-renewable device;

8   (c) determining if said non-renewable device and said renewable device are in

9   cryptographic sync; and

10   (d) returning to step (a) if said non-renewable device and renewable device are not in

11   cryptographic sync.

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4   verifying that said information is received in said predetermined access response

5   window.

1   101.   The method according to claim 98 further comprising the step of:

2   accumulating an error count when said verification is unsuccessful at said renewable

3   device.

1   102.   The method according to claim 101 further comprising the step of:

2   terminating processing by said renewable device if a predetermined error count profile

3   is recognized.

1   103.   The method according to claim 101 wherein the renewable device

2   contains a counter which counts an error prior to the step of verifying, and further

3   comprising the step of:

4   decrementing the counter if verification is successful thereby removing an indication of

5   said error.

1   104.   The method according to claim 103 wherein error is reflected as a NACK.

1   105.   The method according to claim 104 wherein a count of said NACKs is not

2   decremented when said information is received prior to said predetermined access

3   response window.

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4   verifying that said information is received in said predetermined access response

5   window.

1   101.   The method according to claim 98 further comprising the step of:

2   accumulating an error count when said verification is unsuccessful at said renewable

3   device.

1   102.   The method according to claim 101 further comprising the step of:

2   terminating processing by said renewable device if a predetermined error count profile

3   is recognized.

1   103.   The method according to claim 101 wherein the renewable device

2   contains a counter which counts an error prior to the step of verifying, and further

3   comprising the step of:

4   decrementing the counter if verification is successful thereby removing an indication of

5   said error.

1   104.   The method according to claim 103 wherein error is reflected as a NACK.

1   105.   The method according to claim 104 wherein a count of said NACKs is not

2   decremented when said information is received prior to said predetermined access

3   response window.

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2   issuing a new challenge if said non-renewable device and said renewable device are

3   not in cryptographic sync in step (c).

1   111.   The method according to claim 96 wherein if nomeaningful challenge is

2   received from said renewable device, further comprising:

3   sending another seed negotiation request in step (a).

1   112.   The method according to claim 96 further comprising the step of:

2   requesting a NACK status of the renewable device by the non-renewable device;

3   and

4   determining from said challenge, whether the request was honored.

2   issuing a new challenge if said non-renewable device and said renewable device are

3   not in cryptographic sync in step (c).

1   111.   The method according to claim 96 wherein if nomeaningful challenge is

2   received from said renewable device, further comprising:

3   sending another seed negotiation request in step (a).

1   112.   The method according to claim 96 further comprising the step of:

2   requesting a NACK status of the renewable device by the non-renewable device;

3   and

4   determining from said challenge, whether the request was honored.

FIG. 1

FIG. 2

```
  ┌──────────┐          ┌──────────┐          ┌──────────┐
  │  START   │          │  START   │          │  START   │
  │  Source  │          │   CAM    │          │ Backend  │
  └────┬─────┘          └────┬─────┘          └────┬─────┘
       │          S201       │        S204         │
  ┌────▼─────────┐     ┌─────▼──────────┐          │
  │ Send to the  │═════│ Receive from   │          │
  │ CAM          │     │ the Source     │          │
  │ Source_ID    │     │ Source_ID      │          │
  └──────────────┘     └─────┬──────────┘          │
                             │        S205         │        S211
                       ┌─────▼──────────┐     ┌────▼───────────┐
                       │ Send to the    │═════│ Receive from   │
                       │ Backend        │     │ the CAM        │
                       │ CAM_ID,        │     │ CAM_ID,        │
                       │ Source_ID      │     │ Source_ID      │
                       └────────────────┘     └────┬───────────┘
                                                   │        S212
                                              ┌────▼───────────┐
                                              │ Generate       │
                                              │ Cross-         │
                                              │ Certificate    │
                                              └────┬───────────┘
                             S206                  │        S213
                       ┌─────▼──────────┐     ┌────▼───────────┐
                       │ Receive from   │◄════│ Send to the    │
                       │ the Backend    │     │ CAM            │
                       │ Cross-         │     │ Cross-         │
                       │ Certificate    │     │ Certificate    │
                       └─────┬──────────┘     └────┬───────────┘
       S202                  │        S207         │        S214
  ┌────▼─────────┐     ┌─────▼──────────┐        ◄─┴─►
  │ Receive from │◄════│ Send to the    │      ╱  Is    ╲   No
  │ the CAM      │     │ Source         │     ╱ there an  ╲────┐
  │ Cross-       │     │ Cross-         │     ╲ Entity-   ╱    │
  │ Certificate  │     │ Certificate    │      ╲Certificate    │
  └──────────────┘     └─────┬──────────┘       ╲   ?  ╱      │
                             │        S208        ╲──┬─╱       │
                           ◄─┴─►                     │         │
                          ╱  Is  ╲                  Yes        │
                         ╱ there a ╲                 │         │
                         ╲ local    ╱                │         │
                          ╲Entity-  ╱                │         │
                          ╲Certificate                        │
                           ╲  ?  ╱                   │         │
                            ╲─┬─╱                    │         │
                             │ No                    │         │
                    Yes      │        S209           │  S215   │
                     │  ┌────▼──────────┐     ┌──────▼───────┐ │
                     │  │ Receive from  │◄════│ Send to the  │ │
                     │  │ the Backend   │     │ CAM          │ │
                     │  │ Entity-       │     │ Entity-      │ │
                     │  │ Certificate   │     │ Certificate  │ │
                     │  └───────┬───────┘     └──────────────┘ │
                     └──────────┤                              │
       S203                     │        S210                  │
  ┌────▼─────────┐     ┌────────▼──────┐                       │
  │ Receive from │◄════│ Send to the   │                       │
  │ the CAM      │     │ Source        │                       │
  │ Entity-      │     │ Entity-       │                       │
  │ Certificate  │     │ Certificate   │                       │
  └────┬─────────┘     └───────┬───────┘                       │
       │                       │                               │
  ┌────▼─────┐          ┌──────▼───┐          ┌──────────┐◄────┘
  │   STOP   │          │   STOP   │          │   STOP   │
  └──────────┘          └──────────┘          └──────────┘
```

FIG. 3

START
Source

START
CAM

START
Backend

S301
Send to the CAM
Source_ID

S303
Receive from the Source
Source_ID

S304
Send to the Backend
CAM_ID, Source_ID

S308
Receive from the CAM
CAM_ID, Source_ID

S309
Generate
CAM_Priv, CAM_Pub

S310
Generate Cross-Certificate

S305
Receive from the Backend
CAM_Priv

◄secure►

S311
Send to the CAM
CAM_Priv

S306
Receive from the Backend
Cross-Certificate

S312
Send to the CAM
Cross-Certificate

S302
Receive from the CAM
Cross-Certificate

S307
Send to the Source
Cross-Certificate

STOP

STOP

STOP

FIG. 4

```
    ┌─────────────┐          ┌─────────────┐          ┌─────────────┐
    │   START     │          │   START     │          │   START     │
    │   Sink      │          │   CAM       │          │   Backend   │
    └──────┬──────┘          └──────┬──────┘          └──────┬──────┘
           │          S401          │          S404          │
    ┌──────┴──────┐          ┌──────┴──────┐                 │
    │ Send to the │          │ Receive from│                 │
    │ CAM         │═════════▶│ the Sink    │                 │
    │ Sink_ID     │          │ Sink_ID     │                 │
    └──────┬──────┘          └──────┬──────┘                 │
           │                        │          S405          │          S410
         ╱ ╲    S402         ┌──────┴──────┐          ┌──────┴──────┐
        ╱   ╲                │ Send to the │          │ Receive from│
       ╱ Is  ╲               │ Backend     │═════════▶│ the CAM     │
  No──╱ there a╲             │ CAM_ID,     │          │ CAM_ID,     │
      ╲ local  ╱             │ Sink_ID     │          │ Sink_ID     │
      ╲Entity- ╱             └──────┬──────┘          └──────┬──────┘
       ╲Cert? ╱                     │                        │
        ╲   ╱                       │                        │
         ╲ ╱                        │                        │
          │ Yes                     │          S406          │
    ┌─────┴───────┐  S403    ┌──────┴──────┐                 │
    │ Send to the │          │ Receive from│                 │
    │ CAM         │═════════▶│ the Sink    │                 │
    │ Entity-     │          │ Entity-     │                 │
    │ Certificate │          │ Certificate │                 │
    └─────┬───────┘          └──────┬──────┘                 │
          │                         │          S407          │          S411
          │                  ┌──────┴──────┐          ┌──────┴──────┐
          │                  │ Send to the │          │ Receive from│
          │                  │ Backend     │═════════▶│ to the CAM  │
          │                  │ Entity-     │          │ Entity-     │
          │                  │ Cert. Info. │          │ Cert. Info. │
          │                  └──────┬──────┘          └──────┬──────┘
          │                         │                        │
          │                         │                      ╱ ╲   S412
          │                         │                     ╱   ╲
          │                         │                    ╱ Is  ╲
          │                         │                   ╱there a ╲──No──
          │                         │                   ╲ local  ╱      │
          │                         │                   ╲Entity- ╱      │
          │                         │                    ╲Cert? ╱       │
          │                         │                     ╲   ╱         │
          │                         │                      ╲ ╱          │
          │                         │                       │ Yes       │
          │                         │                     ╱ ╲  S413      │
          │                         │                    ╱   ╲          │
          │                         │                   ╱Does ╲         │
          │                         │                  ╱  it   ╲──No──▶ │
          │                         │                  ╲supersede╱       │
          │                         │                  ╲ remote ╱       │
          │                         │                  ╲Ent-Cert╱       │
          │                         │                   ╲   ╱           │
          │                         │                    ╲ ╱            │
          │                         │                     │ Yes         │
          │                         │          S408       │    S414     │
          │                  ┌──────┴──────┐       ┌──────┴──────┐      │
          │                  │ Receive from│       │ Send to the │      │
          │                  │ the Backend │◀══════│ CAM         │      │
          │                  │ Entity-     │       │ Entity-     │      │
          │                  │ Certificate │       │ Certificate │      │
          │                  └──────┬──────┘       └──────┬──────┘      │
          │                         │                     │◀────────────┘
          │                         │                     │    S415
          │                         │              ┌──────┴──────┐
          │                         │              │ Generate    │
          │                         │              │ Cross-      │
          │                         │              │ Certificate │
          │                         │              └──────┬──────┘
          │                         │          S409       │    S416
          │                  ┌──────┴──────┐       ┌──────┴──────┐
          │                  │ Receive from│       │ Send to the │
          │                  │ the Backend │◀══════│ CAM         │
          │                  │ Cross-      │       │ Cross-      │
          │                  │ Certificate │       │ Certificate │
          │                  └──────┬──────┘       └──────┬──────┘
          │                         │                     │
    ┌─────┴───────┐          ┌──────┴──────┐       ┌──────┴──────┐
    │   STOP      │          │   STOP      │       │   STOP      │
    └─────────────┘          └─────────────┘       └─────────────┘
```

FIG. 5

FIG. 6

```
  ┌──────────────┐          ┌──────────────┐          ┌──────────────┐
  │    START     │          │    START     │          │    START     │
  │    Source    │          │     CAM      │          │   Backend    │
  └──────┬───────┘          └──────┬───────┘          └──────┬───────┘
         │             S601        │          S602           │
  ┌──────▼───────┐          ┌──────▼───────┐                 │
  │ Send to the CAM  ├────►  │ Receive from the Source │      │
  │   Source_ID  │          │   Source_ID  │                 │
  └──────┬───────┘          └──────┬───────┘                 │
         │                         │          S603      S605 │
         │                  ┌──────▼───────┐          ┌──────▼───────┐
         │                  │ Send to the Backend ├──► │ Receive from the CAM │
         │                  │ CAM_ID, Source_ID │     │ CAM_ID, Source_ID │
         │                  └──────┬───────┘          └──────┬───────┘
         │                         │                    S606 │
         │                         │                  ┌──────▼────────────────┐
         │                         │                  │ Use Source_ID to lookup Source_Secret │
         │                         │                  └──────┬────────────────┘
         │                    S604 │                    S607 │
         │                  ┌──────▼───────┐          ┌──────▼───────┐
         │                  │ Receive from the Backend │◄─secure─│ Send to the CAM │
         │                  │  Source_Secret │        │  Source_Secret │
         │                  └──────┬───────┘          └──────┬───────┘
  ┌──────▼───────┐          ┌──────▼───────┐          ┌──────▼───────┐
  │     STOP     │          │     STOP     │          │     STOP     │
  └──────────────┘          └──────────────┘          └──────────────┘
```

FIG. 7

```
    ┌──────────┐              ┌──────────┐              ┌──────────┐
    │  START   │              │  START   │              │  START   │
    │  Source  │              │   CAM    │              │ Backend  │
    └────┬─────┘              └────┬─────┘              └────┬─────┘
         │          S701           │          S703           │
    ┌────▼────────┐           ┌────▼──────────────┐          │
    │ Send to the CAM ├──────▶│ Receive from the Source │    │
    │ Source_ID   │           │ Source_ID         │          │
    └────┬────────┘           └────┬──────────────┘          │
         │                         │          S704           │          S708
         │                    ┌────▼──────────────┐     ┌────▼──────────────┐
         │                    │ Send to the Backend ├──▶│ Receive from the CAM │
         │                    │ CAM_ID, Source_ID │     │ CAM_ID, Source_ID │
         │                    └────┬──────────────┘     └────┬──────────────┘
         │                         │                         │          S709
         │                         │                    ┌────▼──────────────┐
         │                         │                    │ Generate Source_Secret │
         │                         │                    └────┬──────────────┘
         │                         │          S705           │          S710
         │                    ┌────▼──────────────┐     ┌────▼──────────────┐
         │                    │ Receive from Backend │◀─secure─┤ Send to CAM    │
         │                    │ Source_Secret     │     │ Source_Secret     │
         │                    └────┬──────────────┘     └────┬──────────────┘
         │                         │                         │          S711
         │                         │                    ┌────▼──────────────┐
         │                         │                    │ Generate           │
         │                         │                    │ (Source_Secret)_Source │
         │                         │                    └────┬──────────────┘
         │                         │          S706           │          S712
         │                    ┌────▼──────────────┐     ┌────▼──────────────┐
         │                    │ Receive from Backend │◀──┤ Send to CAM    │
         │                    │ (Source_Secret)_Source │  │ (Source_Secret)_Source │
         │                    └────┬──────────────┘     └────┬──────────────┘
  S702   │                         │          S707           │
  ┌──────▼──────────┐         ┌────▼──────────────┐          │
  │ Receive from CAM │◀───────┤ Send to Source    │          │
  │ (Source_Secret)_Source │  │ (Source_Secret)_Source │     │
  └──────┬──────────┘         └────┬──────────────┘          │
    ┌────▼─────┐              ┌────▼─────┐              ┌────▼─────┐
    │   STOP   │              │   STOP   │              │   STOP   │
    └──────────┘              └──────────┘              └──────────┘
```

FIG. 8

```
   START                    START                      START
    Sink                     CAM                       Backend
      │                        │                          │
      ▼         S801           ▼          S802            ▼
┌──────────────┐       ┌────────────────────┐
│ Send to the CAM│━━━━━━▶│ Receive from the Source│
│   Sink_ID     │       │     Sink_ID        │
└──────────────┘       └────────────────────┘
                                 │         S803                    S805
                                 ▼                          ▼
                        ┌────────────────────┐    ┌────────────────────┐
                        │ Send to the Backend│━━━▶│ Receive from the CAM│
                        │  CAM_ID, Sink_ID   │    │   CAM_ID, Sink_ID   │
                        └────────────────────┘    └────────────────────┘
                                                             │        S806
                                                             ▼
                                                  ┌────────────────────────┐
                                                  │ Use Sink_ID to lookup Sink_Secret│
                                                  └────────────────────────┘
                                 │         S804                    S807
                                 ▼                          ▼
                        ┌────────────────────┐    ┌────────────────────┐
                        │ Receive from the Backend│◀─secure─│ Send to the CAM   │
                        │    Sink_Secret     │    │   Sink_Secret─     │
                        └────────────────────┘    └────────────────────┘
      │                          │                          │
      ▼                          ▼                          ▼
   STOP                       STOP                       STOP
```

FIG. 9

START Sink	START CAM	START Backend

S901 Send to the CAM Sink_ID → **S903** Receive from the Source Sink_ID

S904 Send to the Backend CAM_ID, Sink_ID → **S908** Receive from the CAM CAM_ID, Sink_ID

S909 Generate Sink_Secret

S905 Receive from Backend Sink_Secret ◄secure— **S910** Send to CAM Sink_Secret

S911 Generate $(Sink\_Secret)_{Sink}$

S906 Receive from Backend $(Sink\_Secret)_{Sink}$ ◄ **S912** Send to CAM $(Sink\_Secret)_{Sink}$

S902 Receive from CAM $(Sink\_Secret)_{Sink}$ ◄ **S907** Send to Source $(Sink\_Secret)_{Sink}$

STOP	STOP	STOP

FIG. 10

204   200   206   408   400   410   300

| Source | | | CAM | | | Sink |

Information | Freshness Generator | CA Decrypt logic | Timer

Source Control Logic | CAM Control Logic

Authentication Logic | Access Window Logic | Authentication Logic | Access Window Logic

STB

208   210   212   412   414   416

100

FIG. 11

```
    ┌─────────────┐        ┌─────────────┐        ┌─────────────┐
    │   START     │        │   START     │        │   START     │
    │   Source    │        │    CAM      │        │    Sink     │
    └──────┬──────┘        └──────┬──────┘        └──────┬──────┘
           │      S1101           │      S1108           │
    ┌──────┴──────┐        ┌──────┴──────┐               │
    │ Send to the │════════│Receive from │               │
    │ CAM         │        │ the Source  │               │
    │ counter,    │        │ counter,    │               │
    │ title       │        │ title       │               │
    └──────┬──────┘        └──────┬──────┘               │
           │                      │      S1109            │
           │               ┌──────┴──────┐               │
           │               │Authenticate │               │
           │               │(counter,    │               │
           │               │title)       │               │
           │      S1102    └──────┬──────┘               │
    ┌──────┴──────┐               │      S1110            │
    │Receive from │        ┌──────┴──────┐               │
    │ the CAM     │◄═══════│Send to the  │               │
    │Authenticate │        │ Source      │               │
    │(counter,    │        │Authenticate │               │
    │title)       │        │(counter,    │               │
    └──────┬──────┘        │title)       │               │
           │      S1103    └──────┬──────┘               │
    ┌──────┴──────┐               │                      │
    │Authenticate │               │                      │
    │(counter,    │               │                      │
    │title)       │               │                      │
    └──────┬──────┘               │      S1111            │
           │      S1104    ┌──────┴──────┐               │
    ┌──────┴──────┐        │Reset the    │               │
    │Reset the    │        │access window│               │
    │access window│        └──────┬──────┘               │
    └──────┬──────┘               │      S1112            │
           │      S1105    ┌──────┴──────┐               │
        ╱──┴──╲            │  Log Play   │               │
   No ╱Authenti-╲          └──────┬──────┘               │
   ◄─╱cations    ╲                │                      │
     ╲match ?    ╱                │                      │
      ╲─────────╱                 │                      │
           │ Yes                  │      S1113            │
           │      S1106    ┌──────┴──────┐               │
    ┌──────┴──────┐        │Receive from │               │
    │Send to the  │═══════►│ the Source  │◄────┐         │
    │CAM          │        │CA(Information)│    │         │
    │CA(Information)│      └──────┬──────┘     │         │
    └──────┬──────┘               │      S1114  │         │
           │               ┌──────┴──────┐     │         │
   No      │               │Decrypt      │     │         │
           │               │Information  │     │         │
           │               │from         │     │         │
           │               │CA(Information)│   │         │
           │               └──────┬──────┘     │         │
           │                      │      S1115  │    S1117│
           │               ┌──────┴──────┐   ┌─┴────────┴──┐
           │               │Send to the  │═══│Receive from │
           │      S1107    │Sink         │   │the CAM      │
        ╱──┴──╲            │Information  │   │Information  │
       ╱Has the╲           └──────┬──────┘   └──────┬──────┘
      ╱content  ╲                 │      S1116        │
      ╲window   ╱              ╱──┴──╲                │
       ╲expired?╱             ╱Has the╲  No           │
        ╲──┬──╱              ╱content  ╲───┘           │
           │ Yes            ╲window    ╱               │
           │                 ╲expired? ╱               │
    ┌──────┴──────┐           ╲──┬──╱                 │
    │    STOP     │              │ Yes                 │
    └─────────────┘       ┌──────┴──────┐       ┌──────┴──────┐
                          │    STOP     │       │    STOP     │
                          └─────────────┘       └─────────────┘
```

FIG. 12

```
      ┌──────────────┐                        ┌──────────────┐
      │    START     │                        │    START     │
      │   Source     │                        │     CAM      │
      └──────┬───────┘                        └──────┬───────┘
             │              S1201                    │           S1207
      ┌──────▼───────────┐              ┌─────────────▼────────────┐
      │  Send to the CAM │─────────────▶│   Receive from the Source│
      │ Time Remaining   │              │   Time Remaining request,│
      │ request,         │              │      counter, title      │
      │ counter, title   │              └─────────────┬────────────┘
      └──────┬───────────┘                            │           S1208
             │                           ┌────────────▼─────────────────────┐
             │                           │ Authenticate(counter,actual time  │
             │                           │           remaining)              │
             │              S1202        └────────────┬─────────────────────┘
      ┌──────▼──────────────────────┐                 │           S1209
      │  Receive from the CAM       │   ┌─────────────▼────────────────────────┐
      │  actual time remaining      │◀──│        Send to the Source             │
      │  Authenticate(counter,      │   │        actual time remaining,         │
      │  actual time remaining)     │   │  Authenticate(counter, actual time    │
      └──────┬──────────────────────┘   │             remaining)                │
             │              S1203        └─────────────┬────────────────────────┘
      ┌──────▼──────────────────────┐                 │
      │ Authenticate(counter,       │                 │
      │ actual time remaining)      │                 │
      └──────┬──────────────────────┘                 │
             │              S1204                      │
          �◊                                    │
      Authentications                                 │
          match                                       │
            ?                                          │
      Yes ╱      ╲ No                                  │
  ┌────────▼──┐  ┌────▼────────┐                       │
  │ S1205     │  │  S1206      │                       │
  │TimeRemain-│  │TimeRemaining│                       │
  │ing = YES  │  │  = NO       │                       │
  └────┬──────┘  └────┬────────┘                       │
       │              │                                │
       └──────┬───────┘                                │
              │                                        │
      ┌───────▼──────┐                        ┌────────▼─────┐
      │    STOP      │                        │    STOP      │
      └──────────────┘                        └──────────────┘
```

FIG. 13

FIG. 14

START
Source

S1401
Send to the CAM
counter, title,
request for ProcessWindow

S1402
Receive from the CAM
Authenticate(counter,ProcessWindow,
title)

S1403
Authenticate(counter,ProcessWindow,
title)

S1404
Authentications
match
?

No

Yes

S1405
Extend AccessWindow by
ProcessWindow

S1406
Send to the CAM
CA(information)

S1407
Has AccessWindow
expired?

No

Yes

STOP

START
CAM

S1408
Receive from the Source
counter, title,
request for ProcessWindow

S1409
Authenticate(counter,ProcessWindow,
title)

S1410
Send to the Source
Authenticate(counter,ProcessWindow,
title), ProcessWindow

S1411
Log play of ProcessWindow

S1412
Extend AccessWindow by
ProcessWindow

S1413
Receive from the Source
CA(information)

S1414
Decrypt content_data
from CA(information)

S1415
Send to the SINK
information

S1416
Has AccessWindow
expired?

No

Yes

STOP

START
Sink

S1417
Receive from the CAM
information

STOP

FIG. 15

FIG. 16

FIG. 17

204c   200c   222c   422c   408c   400c   426c   304c   300c   500

| Source | | CAM | | | Sink | | Output Device |

- Information
- Super Encrypt
- Super Decrypt
- CA Decrypt
- Interface Encrypt
- Interface Decrypt

Source Control Logic   CAM Control Logic   Sink Control Logic

208c   412c   306c

Backend System

700

FIG. 18

START
Source

START
CAM

START
Sink

S1801
Send to the CAM
Title

S1804
Receive from the Source
Title

S1805
Use Title to key the decryptor

S1802
Super-encrypt(CA(Information))

S1806
Make a log entry of the Title

S1807
Receive from the Sink
SinkCounter

S1814
Send to the CAM
SinkCounter

S1808
Derive a CAM/Sink session key

S1815
Derive a CAM/Sink session key

S1803
Send to the CAM
Super-encrypt(CA(Information))

S1809
Receive from the Source
Super-encrypt(CA(Information))

S1810
Super-decrypt the
Super-encrypt(CA(Information))

S1811
CA-decrypt the CA(Information)

S1812
Re-encrypt the Information
using the CAM/Sink session key

S1813
Send to the Sink
Re-encrypted Information

S1816
Receive from the CAM
Re-encrypted Information

S1817
Decrypt the Information
using the CAM/Sink session key

STOP

STOP

STOP

FIG. 19

FIG. 20

FIG. 21

FIG. 22

FIG. 23

```
   ┌──────────────┐                        ┌──────────────┐
   │    START     │                        │   START      │
   │    Source    │                        │    CAM       │
   └──────┬───────┘                        └──────┬───────┘
          │                    S2301              │              S2305
          ▼                                       ▼
   ┌──────────────┐◄─────┐          ┌──────────────────┐
   │Receive from the CAM │◄─────────│  Send to the Source │
   │     Random          │          │       Random        │
   └──────┬──────────────┘          └──────┬──────────────┘
          │              S2302                    │            S2306
   ┌──────▼──────────────┐          ┌──────▼──────────────┐
   │ Authenticate(random, title)    │ Authenticate(random, title) │
   └──────┬──────────────┘          └──────┬──────────────┘
          │              S2303                    │            S2307
   ┌──────▼──────────────┐          ┌──────▼──────────────┐
   │ Send to the CAM     │─────────►│ Receive from the Source │
   │ Authenticate(random, title)    │ Authenticate(random, title) │
   └──────┬──────────────┘          └──────┬──────────────┘
          │              S2304                    │       S2308        S2309
   ┌──────▼──────────────┐                 ◇ Authentication ◇──Yes──►┌──────────────┐
   │ Increment random    │                 ◇    match ?     ◇        │Increment random│
   └─────────────────────┘                 ◇               ◇        └──────────────┘
                                                    │ No
                                             ┌──────▼───────┐
                                             │    STOP      │
                                             └──────────────┘
```

FIG. 24

FIG. 25

START Source

S2501 Send to the CAM counter,title

S2502 Receive from the CAM cam-counter, Authenticate(counter, title, cam-counter)

S2503 Authenticate(counter, title, cam-counter)

S2504 Authentications match ?

Yes

S2505 Send to the CAM Authenticate(cam-counter,session key evidence)

S2506 increment cam-counter

S2507 Send to the CAM Super-encrypt(CA(information))

No

STOP

START CAM

S2508 Receive from the Source counter,title

S2509 Authenticate(counter, title, cam-counter)

S2510 Send to the Source cam-counter, Authenticate(counter, title, cam-counter)

S2511 Make a LOG entry

S2512 Receive from the Sink SinkCounter

S2513 Derive a CAM/Sink session key

S2514 Authenticate(cam-counter,session key evidence)

S2515 Receive from the Source Authenticate(cam-counter,session key evidence)

S2516 Authentications match ? — No

Yes

S2517 increment cam-counter

S2518 Receive from the Source Super-encrypt(CA(information))

S2519 Super-decrypt the Super-encrypt(CA(information))

S2520 CA-decrypt the CA(information)

S2521 Re-encrypt the information using the CAM/Sink session key

S2522 Send to the Sink Re-encrypted information

STOP

START Sink

S2523 Send to the CAM SinkCounter

S2524 Derive a CAM/Sink session key

S2525 Receive from the CAM Re-encrypted information

S2526 Decrypt the information using the CAM/Sink session key

STOP

FIG. 26

FIG. 27

INTERNATIONAL SEARCH REPORT	International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04K 1/00, 1/02; H04N 7/167
US CL   :380/10,20,23,25

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 380/10, 20, 23, 25

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 5,757,918 A (HOPKINS) 26 MAY 1998, see the whole document	1-96, 111, and 112
X	US 5,694,471 A (CHEN ET AL.) 02 DECEMBER 1997, see the whole document.	1-96, 111, and 112
X	US 4,935,962 A (AUSTIN) 19 JUNE 1990, see the whole documnet.	1-96, 111, and 112

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
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"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 JUNE 1999	**08 JUL 1999**
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington. D.C. 20231	Authorized officer GAIL HAYES
Facsimile No. (703) 305-3230	Telephone No. (703) 306-4169

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